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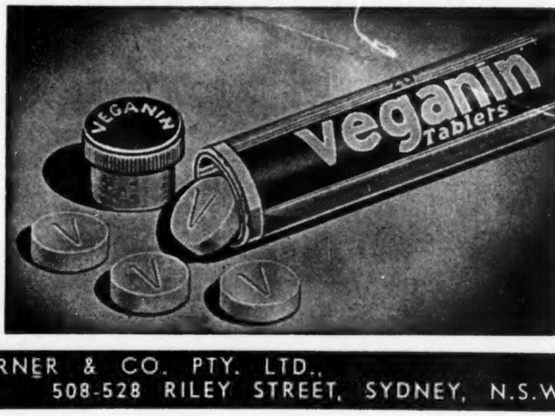

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NEUROPHYSIOLOGICAL ASPECTS OF MASTICATION*

J. P. WALSH, M.B., B.S., D.D.Sc. (MELB.), F.D.S.R.C.S. (ENG.)

Maintenance and restoration of normal masticatory function are the basic objectives of most branches of dentistry. Nevertheless, the exact mechanism of mastication, despite much work in recent years, is still incompletely understood. The writings of Sicher[1] on anatomy, Brodie[2] and Thompson[3] on growth and development, and Moyers[4] on muscle function, have clarified some controversial issues, but the neurophysiology of the masticatory mechanism has received little attention. For example, Best and Taylor[5], in one of the most comprehensive textbooks on applied physiology, devote but fourteen lines to the masticatory mechanism. (This neglect of the field by physiologists is a typical effect of the separation of dentistry and medicine.)

At present, the starting point for much clinical work is the concept that the rest position of the mandible remains unchanged and eccentric functional patterns can be determined by an analysis of the path of closure from rest through the point of initial contact to final occlusion. However, in my opinion, the concept of a fixed rest position is not physiologically tenable. Although this idea has clinical value in some cases, it may be misleading in others, both in diagnosis and treatment.

To clarify the problem, it is necessary to consider the reflex neuromuscular mechanisms of mastication and posture, and their inter-relationships. According to McLeod[6], "mastication is an unconditioned reflex, that is, it occurs automatically as a result of appropriate stimulation. However, modification of the conditions under which these inborn responses occur may be brought about as a result of experience or training, and these responses to new forms of stimuli are called conditioned reflexes." On the other hand, the rest position of the mandible is generally considered to be governed by postural reflexes. The fundamental question, so far unanswered in considering the rest position, is the relationship between the anti-gravity reflexes controlling the postural position of the mandible,

*Read at the Twelfth Australian Dental Congress, Sydney, August, 1950.

1. Sicher, H.—Oral Anatomy, St. Louis, C. V. Mosby Co., 1949, p. 164.
2. Brodie, A. G.—Am.J.Orth. & Oral Surg., 26:741, 1940.
3. Thompson, J. R.—Angle Orth., 19:162, 1949.
4. Moyers, R. E.—Am.J.Orth., 35:837, 1949.
5. Best and Taylor—Ed. 4, Baltimore, Williams & Wilkins Co., 1945, p. 478.
6. McLeod's Physiology in Modern Medicine, Ed. 9, St. Louis, C. V. Mosby Co., 1941, p. 232.

and the reflexes controlling mastication. Are both reflex mechanisms concerned, and to what extent? May their effect be cumulative or antagonistic? For example, if an alteration in occlusal relationships affects masticatory function, will the newly-established conditioned reflexes modify the rest position, even although this has been correctly regarded as primarily under the control of postural reflexes?

Before considering the possible inter-relationships of the two mechanisms, each must be considered separately.

The Masticatory Reflex.

The masticatory reflex begins by stimulation of afferent nerve endings consisting of muscle spindles of the masticatory muscles and receptors in the periodontal membrane, gums, palate and tongue. Ranson[7] in a drawing from

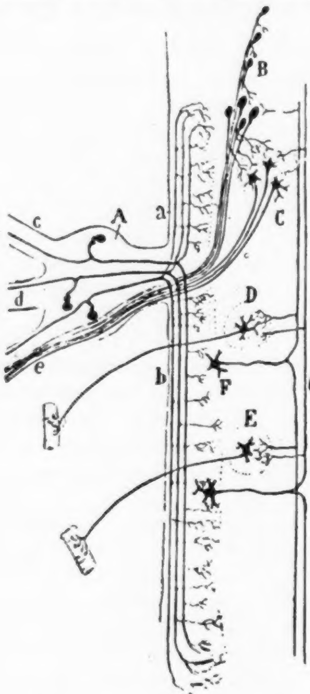

Fig. 1.—Diagram of the nuclei and central connections of the trigeminal nerve; *A*, semi-lunar ganglion; *B*, mesencephalic nucleus, N.V; *C*, motor nucleus, N.V; *D*, motor nucleus, N.VII; *E*, motor nucleus, N.XII; *F*, nucleus of the spinal tract of N.V; *G*, sensory fibres of the second order of the trigeminal path; *a*, ascending and *b*, descending branches of the sensory fibres, N.V; *c*. opthalmic nerve; *d*, maxillary nerve; *e*, mandibular nerve. (Cajal). *By courtesy of W. B. Saunders Publishing Co.*

Cajal, illustrates the nuclei and central connections of the trigeminal nerve, including fibres in the mandibular division passing to the mesencephalic nucleus. (Fig. 1).

7. Ranson, S. W.—The Anatomy of the Nervous System, Ed. 6, Philadelphia, W. B. Saunders Co., 1942, p. 152.

Szentagothai[8] demonstrated that the afferent fibres from masticatory muscle spindles enter the brain-stem via the *motor* root of the fifth nerve and make monosynaptic connections with trigeminal motor-neurones, their cell bodies being situated in the mesencephalic nucleus of the fifth nerve. McIntyre[9] has confirmed this by demonstrating spindle discharges in the motor root on stretching

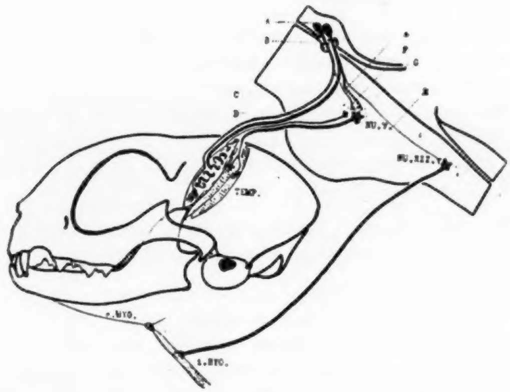

Fig. 2.—Diagram showing stretch reflex arc of masticatory muscles. A: mesencephalic tract neurons; B: site of lesion; C: fibre of medium calibre terminating in neuromuscular spindle as a single flower-spray ending; D: large afferent fibre terminating as annulospiral ending; E: reflex collaterals to masticatory nucleus (NU.V); F: motor neuron supplying intrafusal muscle fibres; G: motor neurons for masticatory muscles; H: descending collaterals to nuclei of infrahyoid muscles; NU.XII; hypoglossal nucleus. Reproduced from an article in *J. Neurophysiology* by Szentagothai.

the masticatory muscles and showing the persistence of monosynaptic (myotatic or stretch) reflex responses in the masticatory muscles after section of the sensory root of the fifth nerve. (Fig. 2).

Corbin and Harrison[10] have shown by oscillographic experiments that afferent mesencephalic root fibres also enter the alveolar (dental) and palatine nerves. These impulses prevent damage to the teeth and gums in mastication. These impulses and those passing via the masticatory nerves constitute the afferent limbs of masticatory reflex arcs, which co-ordinate and control the movements of mastication.

Sherrington[11] and Pfaffman[12] have shown that mechanical stimulation of the maxillary nerve causes reflex jaw-opening, and Sherrington showed that, in the decerebrate cat, pressure stimulation of teeth, gums and palate cause reflex inhibition of the elevator muscles, and jaw-opening results. Stretching of the

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8. Szentagothai, J.—J. Neurophys., 11:445, 1948.
9. McIntyre—Personal communication, 1950.
10. Corbin, K. B. & Harrison.—J. Neurophys., 3:423, 1940.
11. Sherrington, C. S.—J. Physiol., 51:404, 1917. *idem*—Selected writings of Sir Charles Sherrington (Ed. D. Denny Brown), Hamish Hamilton, 1939, p. 191.
12. Pfaffman, C.—J. Physiol., 97:207, 1939.

muscles stimulates the muscle spindle afferents, causing reflex closure and thus the rhythmic opening and closing movements of mastication are reflexly controlled.

It will be noted that none of these authors has investigated the possible role of afferent impulses from the temporomandibular joints. It seems possible that afferents from the joints would be concerned in the masticatory mechanism and an investigation is indicated.

Alteration in the occlusal relationship of teeth will affect afferents in the periodontal membrane, thus reflexly altering the masticatory function. For example, a premature contact causing a traumatic occlusion will set up inhibitory impulses along the sensory nerves from endings in the periodontal membrane. In order to masticate, the muscular balance must be changed so that the "high spot" is avoided. This is done by a shift of the whole mandible, and a new conditioned reflex is soon established.

In general the mandible will adopt a position which distributes the masticatory load on the periodontal membrane of the teeth as evenly as possible.

The activity of these relatively simple reflex arcs is usually considered to be relatively fixed or stable, a stereotyped response always following a given pattern of afferent impulses. Recently, however, evidence has been accumulated (Eccles and McIntyre, unpublished), which indicates a certain measure of plasticity or adaptability of similar reflex arcs in the spinal cord.

So far we have considered the lower level of reflex function, but even at this level, adaptibility is apparent. Unconditioned reflexes are not unchanging in character; conditioning can occur even at the lowest level of reflex activity.

There are, however, many higher levels of control. Afferents also pass to the thalamus and cortex and efferents pass from the mid-brain motor centres, and the premotor and motor cortex. These in turn are influenced by impulses from the cerebellum and other centres. Sherrington[13] demonstrated cortical representation of masticatory movements in the cat. As he expresses it, "the reflex tends to exhibit a single complete bite, the cortical reaction a performance of mastication." At the cortical level, conscious control of mastication is established, and here conditioned reflexes play a major role in modifying the masticatory reflex. Ballard and Gwynne-Evans[14] emphasize the importance of the stage of development of the central nervous system in determining muscle behaviour and in correcting abnormal habits. Habit patterns of movement are readily established. Here again, prime control rests with the afferent impulses and these depend largely on the occlusal tooth relationships.

Sicher[15] compares mastication with walking and emphasizes the adaptability of the mechanism. Another point he mentions is important: "the muscle pattern operates with the least waste of muscular energy . . . . . loss of teeth or changes in their position are followed by rapid adaptation of movements in order to achieve maximum effect with minimum effort."

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13. Sherrington, C. S.—*op. cit.*
14. Ballard, C. F. and Gwynne-Evans, E.—Dent. Rec., 68:1, 1948.
15. Sicher, H.—*op. cit.*

THE REST POSITION AS A POSTURAL REFLEX.

The physiological rest position is maintained by the tonus of the elevator muscles. This tone depends on stretch reflexes; the muscle spindles in the antigravity muscles are stimulated by the tendency of gravity to lengthen the muscles, and reflex contraction occurs. This effect of gravity on the jaw muscles is determined by head posture. As Smithels[16] points out, the reflex tonus is affected by head-neck-thorax posture—"those with poking heads have sagging

Fig. 3.—Changes in head position produced by physical and postural training. *Left side*—before training; *right side*—after training.

jaws." Changes in jaw-position and musculature due to changes in head posture (produced by physical and postural training) have been recorded by Jokl[17] and others. (Figs. 3-5.)

Like the masticatory reflex, the postural reflex is affected by higher centres up to the level of conscious cortical control. Again to quote Smithels—"the principles of postural re-education which have long been established are that the postural reflex can be modified by use or habit and altered by conscious cortical control. The process of motor learning is mostly a matter of conscious understanding of the process involved, analysis of the movement to be made, kinaesthetic appreciation of the new position required and conscious establishment of new habits which soon after become reflexes." Rathbone[18] states "reflex arcs can be trained by many repetitions of a specific act until the reflexes become conditioned to work without conscious control. It has been observed repeatedly

16. Thompson, J. R. and Brodie, A. G.—J.A.D.A., 29:925, 1942.
17. Jokl, E.—Pub. of S.A. Inst. for Med. Research, April, 1941, p. 126.
18. Rathbone, J.—Corrective Physical Education, Philadelphia, W. B. Saunders Co., 1944, p. 63.

that, if posture be maintained by conscious effort long enough, then the increase of reflex tonus obtained by such practice will serve to maintain the same attitude without the further need of thought or attention."

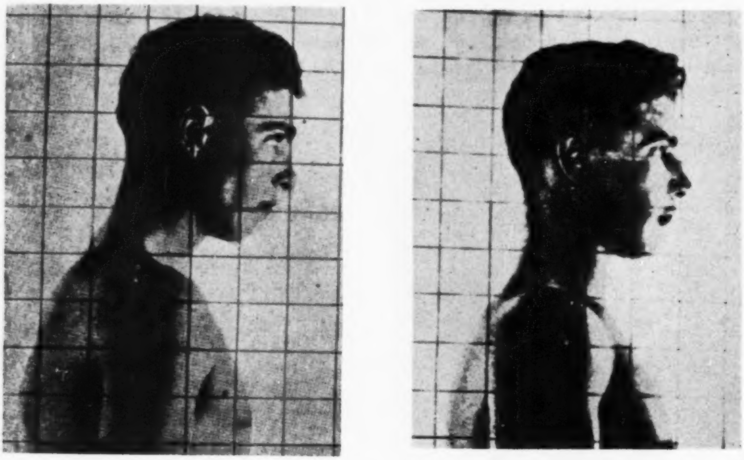

Fig. 4.—Changes in head position produced by physical and postural training. *Left side*—before training; *right side*—after training.

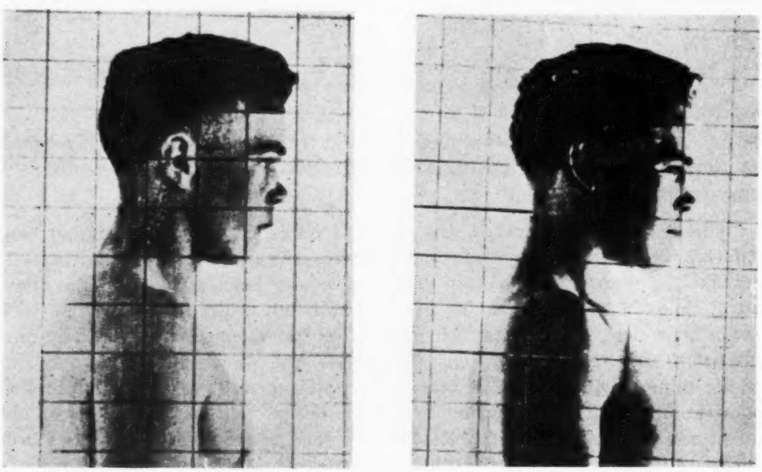

Fig. 5.—Changes in head position produced by physical and postural training. *Left side*—before training; *right side*—after training.
Figs. 3, 4 and 5 from an article by E. Jokl, a publication of S.A. Inst. for Med. Research.

Again, the reflex tonus of the elevator muscles of the mandible is affected by such factors as skin temperature; fatigue; emotional states, such as anger and fear; and mental states such as determination, concentration, and surprise.

To sum up, the various neurological factors controlling the mechanisms of mastication and posture are:

1. the prominent role of stimuli affecting afferent nerve endings;
2. the adaptability or plasticity of the reflex arc, even at the lowest neurological level;
3. the tendency of muscle movements to achieve maximum effect with minimum effort;
4. the fact that conscious control once established on a habitual basis becomes a conditioned reflex.

Interaction of the Masticatory Reflex and the Postural Reflex in Determining the Physiological Rest Position.

It will have been noted that the same sensory nerve endings, the muscle spindles, serve both the masticatory and postural reflexes; the same afferent pathways are used and both are under cortical control. It seems reasonable to deduce that modification of masticatory function will affect the rest position.

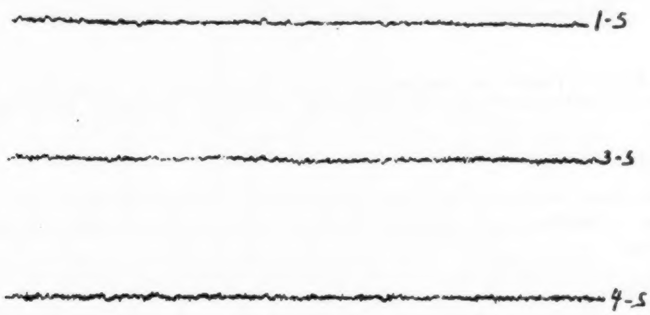

Fig 6.—*1-5*, Anterior fibres of temporal; *3-5*, middle fibres; *4-5*, posterior fibres. Note the uniformity of "tonus." From an article by R. E. Moyers in the *American Journal of Orthodontics*.

This hypothesis is being investigated at present by workers at the National Dental School in Dunedin. Most writers, in considering rest position, pay particular attention to the vertical dimension and neglect the other dimensions, yet a three-dimensional concept is essential. Moyers[19] has pointed out that, in some patients with Class II (Angle) malocclusion, the resting tonus in the temporal muscles differs from the normal in that the posterior retractor fibres of the temporal muscle are overactive. (Figs. 6, 7.) This is a most significant observation. Even Thompson[20] who has contributed much to our understanding of the masticatory mechanism states: "the spatial position of the mandible is an individual characteristic which is as stable as any part or any other

19. Moyers, R. E.—*op. cit.*
20. Thompson, J. R. & Brodie, A. G.—*op. cit.*

relationship." Later[21] he states: "there is much that is not known about the mandibular rest position and its variables." However, Thompson does not consider the presence or absence of teeth has much bearing on the rest position, but his work was mainly concerned with the vertical dimension.

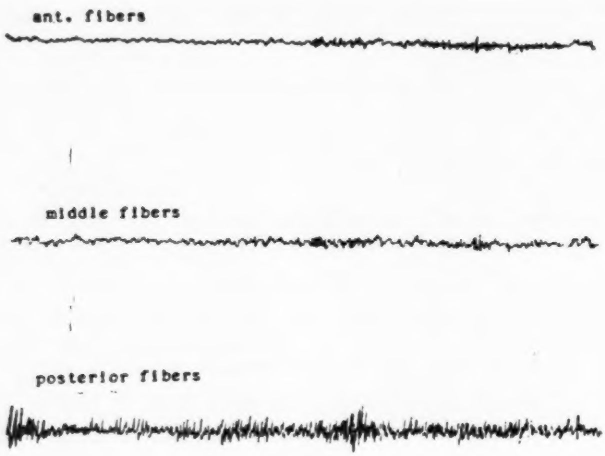

Fig. 7.—K.L.J. "Tonus" in resting temporal muscle prior to orthodontic Therapy. From an article by R. E. Moyers in the *American Journal of Orthodontics*.

Analysis of Jaw Movement between Rest and Function.

While much attention has been given to closing movements of the mandible from rest to function, less attention has been given to the opening movements of mastication.

Case Analysis.

A patient recently observed in New York had had the whole of the right ramus and a major portion of the right side of the body of the mandible removed some weeks previously. The incisors in both jaws were still present. When first observed, the mandible deviated considerably to the right. On being asked to close the jaw the patient brought the lower jaw up by a simple hinge closure to the point of initial contact of the incisors. At this first attempt, the initial contact was well to the right. Immediately contact was established, the patient's lower incisors moved along the inclined planes of the lingual surfaces of the upper incisors into the terminal functional position. The patient was then asked to repeat the movement. On reopening the mandible, the deviation was considerably reduced and the second closure brought the mandible almost into the terminal functional position by a simple closure, a slight sliding movement, of lesser magnitude than before, completing the movement. At the third attempt the mandible closed directly into the terminal functional position and opened by a simple

21. Thompson, J. R.—*op. cit.*

hinge movement to a central position. The mandible returned directly to the functional position with all further attempts. In terms of the principles stated earlier, the neuromuscular mechanism had rapidly adapted itself to the loss of half the mandible. In this example, the patient had learnt to compensate for the loss of the entire musculature on one side, and only three attempts at closure were required to refresh the neuromuscular "memory" established during the weeks following the operation. The patient, moreover, did not return to the deviated rest position during function. Craddock[22] has recently described a case in which the patient had learned to maintain a central position in rest, even though half the mandible had been removed.

Now, let us consider in more detail the movements of the mandible from rest position and select an arbitrary point, the gnathion or chin point, for our observations. Call the gnathion in the rest position in the normal individual point A. (Fig. 8.) The mandible closes to the terminal functional position by

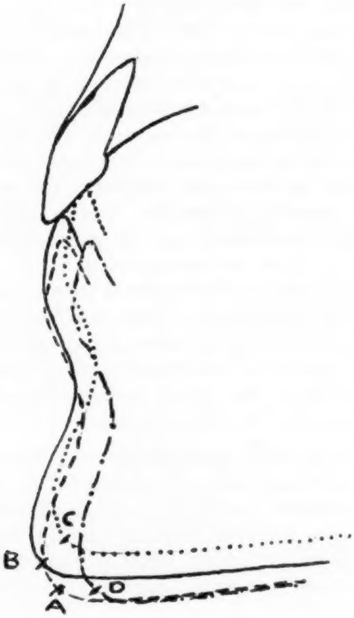

Fig. 8.—(See text.) A, B, C, D represent positions of gnathion: A, at rest; B, at point of initial contact; C, at terminal functional position; D, at retruded position.

a simple hinge closure, the gnathion moving in an arc of a circle upwards and slightly forward. Let us call this position of the gnathion with the mandible in centric occlusion or normal terminal functional position point B. Normal

22. Craddock, F. W.—N.Z.D.J., 46: July, 1950.

movements from rest to function and back can then be represented by the formula A-B-A, the mandible returning to the rest position by a simple hinge movement, B-A. Now let us assume that the patient loses all posterior teeth and, deprived of occlusal support, is forced to adopt a displacement of the mandible upward and backward, the lower incisors sliding up the lingual aspect of the upper incisors. The terminal functional position is thus displaced up and back and so is the gnathion; let us call this point C. The closing movement is thus represented by the formula A-B-C as the mandible closes by a simple hinge closure to the point of initial contact and then, under the influence of occlusion, moves into the upward and retruded position. So far we are on firmly established ground but we are not so certain of what happens after this. It is apparently assumed that the mandible opens along the same path and the complete formula would then read A-B-C-B-A. In terms of the principle mentioned by Sicher, that muscle movements tend to operate with least waste of effort, this complicated movement is soon simplified or "smoothed out." The closing movement becomes A-C, the patient learning to close directly into the functional position, although the A-B-C movement can still be demonstrated where the habit is not long-established. The opening movement similarly may follow the closing movement and the formula would then read A-C-A. This combination of hinge and sliding movement is, however, not the simplest movement possible. Opening the mandible to the rest position is not an active conscious movement nor is it influenced by occlusal contact. A simple hinge opening movement from point C will, however, result in a slight retrusion of the mandible, the gnathion moving to a new point, D. Opening and closing movements could then follow the simple formula D-C-D. The patient now has two open positions: the old, normal rest position, and a "new" position, adopted to simplify muscle action and used whenever occlusal contact has been established, *e.g.*, in mastication or swallowing. This retruded position may in time become accepted as the habitual rest position. These four positions can be demonstrated where the retruded abnormal functional position has not been long established. There is a true rest position, but simple hinge closure from this position to the point of initial contact is of no functional use to the patient; and there is a retruded position from which simple hinge closure brings the mandible to the actual terminal functional position accepted by the patient, and caused by the malocclusion.

In my opinion, it is not safe to accept a rest position obtained immediately after the patient has made an occlusal contact. The rest position should be determined under standardised conditions so that afferent stimuli arising from the masticatory reflex are minimal, and all factors which alter the postural reflex are controlled. I do not accept without reservation the statement that the most retruded position is normal, particularly if occlusal disharmony is present.

As stated by me in a previous paper[23], it must be emphasized that retrusion, protrusion, or lateral displacement only occurs according to the occlusal pattern. The edentulous patient with resorbed ridges and old dentures will develop a simple overclosure. Point C is then on the same arc as A-B, and the rest position remains unchanged. Arthritic symptoms often develop in these cases due to the fact that function is only possible with the teeth in occlusion, and bringing

23. Walsh, J. P.—N.Z.D.J., 45:233, 1949.

the teeth into occlusion by overclosure will force the condyle head to rotate backwards into the posterior sector portion of the joint, which is not provided with dense fibrous tissue designed to resist pressure.

The Role of the Temporomandibular Joint and the Tooth-supporting Tissues.

It is probable that proprioceptive impulses from the temporomandibular joint affect the masticatory reflex. In patients with arthritis, stimulation of pain endings produces inhibition of the reflex, initiating the establishment of new conditioned reflexes, with the patient tending to favour the injured joint and restrict its movement. If forward movement causes pain, the patient will tend to masticate on the affected side. Similarly, if the condyle is forced by the occlusal pattern into a retruded position during mastication, painful stimuli

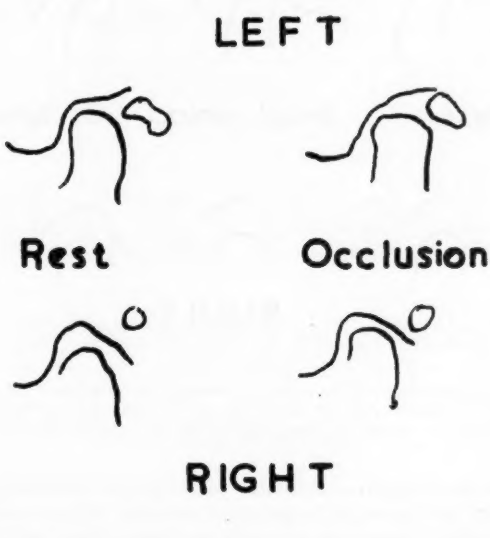

Fig. 9.—Tracings from temporomandibular joint radiographs (Lindblom technique), showing retrusion of condyle in moving from rest to occlusion, particularly on right side.

will arise during the masticatory cycle. Such a patient will readily adopt a normal position forward of the retruded position, if the "bite" is opened and the occlusal deformity corrected either by a temporary splint or by more permanent restorative or prosthetic procedures.

Using the analogy adopted by Sicher, a person with a nail in his shoe adopts an abnormal mode of walking, favouring the tender foot, but quickly reverts to his habitual movements when the abnormal painful stimulus is removed.

However, long-established abnormal patterns of behaviour, such as occur in the masticatory mechanism, will not so readily respond to treatment. The time taken for reconditioning will not only depend on the length of time the faulty mechanism has been established and the rate of its development, but also on the extent of the abnormality and on the pathological changes being produced in the joint and the supporting structures of the teeth.

Joints permanently damaged by occlusal deformity or irreversible damage to the periodontal membrane cannot be expected to recover when the pathological stimulus is removed. In essence, it is impossible in some cases to restore normal function.

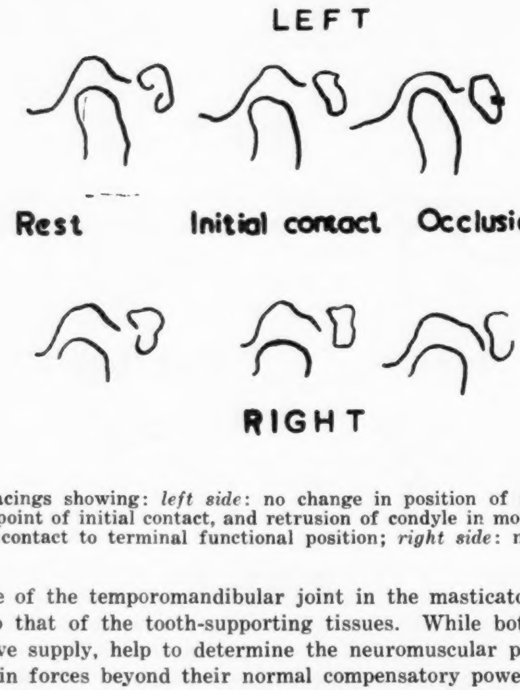

Fig. 10.—Tracings showing: *left side*: no change in position of condyle in moving from rest to point of initial contact, and retrusion of condyle in moving from point of initial contact to terminal functional position; *right side*: no retrusion.

The role of the temporomandibular joint in the masticatory mechanism is analogous to that of the tooth-supporting tissues. While both, through their afferent nerve supply, help to determine the neuromuscular pattern, they may be involved in forces beyond their normal compensatory powers with resulting degenerative changes. However, forces which are gradual in onset or mild in degree may be within physiological limits and compensatory changes in both structures will then occur. These changes occur mainly in the bone. As King[24] points out, bone is one of the most plastic of connective tissues.

The age of the patient is another factor of importance. If an abnormal occlusal pattern occurs during the period of growth and development, adaptive changes will occur in the temporomandibular joint, with remodelling of the condyle head and the articular area of the temporal bone. Such changes may

24. King, E. S. J.—Aust.J.Dent., 54:147, 1950.

be symptomless, but the modifications occurring in muscular function may produce profound changes in the whole lower facial architecture. As Krogman[25] states, "Pattern at most can be merely the framework within which the growth impulse expresses itself and is modifiable by whatever endogenous and exogenous factors may be impacted upon it." The idea of an unchanging stable growth pattern is just as untenable as the idea of an unchanging stable rest position.

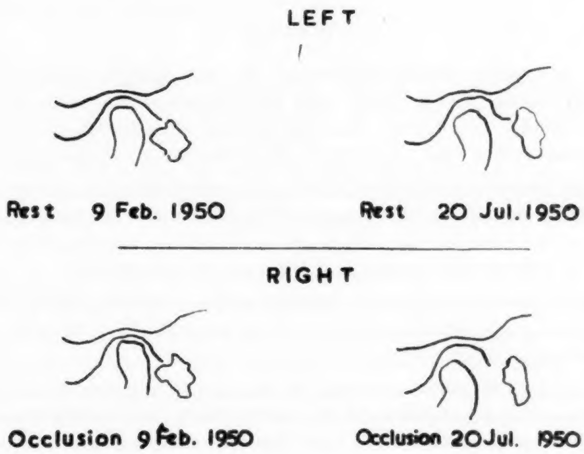

Fig. 11.—Tracings from temporomandibular joint radiographs (Lindblom technique), showing change in rest and occlusal positions following treatment with removable acrylic splint.

Clinical Considerations.

The concept that the rest position may change, due to changes in either the postural or masticatory reflexes, increases our diagnostic and therapeutic problems. However, the neurophysiological concept explains the difficulty some patients have when the dental practitioner seeks to restore normal occlusion. The patient may have to relearn a long-forgotten neuromuscular pattern or learn a new pattern. At the cortical level psychosomatic factors are involved and the patient must have the will to be re-educated. If, however, the patient has suffered pain or other arthritic symptoms as a result of functioning about the abnormal position, and the restoration of normal occlusion brings relief, he will, by conscious effort, soon adapt himself to the changed occlusion. Some patients find difficulty in returning to the normal in one stage and have to be treated by gradual alteration in the functional position. The re-education of

25. Krogman, L. G.—Oral Surg., Oral Med. & Oral Path., 3:446, 1950.

muscles takes some time, and the habit pattern must become an unconscious conditioned reflex before final success is assured. It must be again emphasized that a permanently damaged joint, due to long standing or severe displacement, cannot be expected to recover when restoration of normal occlusion produces a normal functional position of the condyle and the mandible. Another clinical problem is presented when it is necessary to increase the length of the crowns of teeth with occlusal onlays when occlusal trauma has already partly destroyed their supporting tissues. Although such treatment may be indicated, to protect the joint from further injury, it may produce further periodontal damage.

SUMMARY.

1. The dominant forces controlling the masticatory mechanism are the occlusal relationship of the teeth and the neuromuscular reflexes originating in sensory stimuli to afferent endings in the periodontal membrane, muscle spindles, gums, palate and (probably) the temporomandibular joints.

2. In the temporomandibular joints and supporting structures of the teeth, compensatory or degenerative changes follow alterations in masticatory function, the nature of the reaction depending on such factors as the rate, duration and magnitude of the applied forces, and the age of the patient.

3. As masticatory reflexes and postural reflexes affecting masticatory muscles follow common neurological pathways, it is unlikely that the two mechanisms are independent of each other.

4. The great difficulties involved in the correct diagnosis and treatment of patients where the breakdown of the masticatory mechanism has reached the symptomatic level emphasizes the need for early recognition and correct treatment of malocclusion.

5. Finally and most important, all branches of dentistry must reorientate their teaching around the concept of maintenance and restoration of normal masticatory function. Seward[26] has long encouraged this concept. In a sense, the idea brings together the various branches of dentistry and alters their mode of thought, in a manner comparable to the earlier concept of oral sepsis in its relationship to general health.

CONCLUSION.

This review of the neurophysiology of mastication and posture is intended to indicate the possible lines of future research needed to elucidate the problems of mastication. In the present state of our knowledge it is unwise to postulate rigid concepts. The application of the basic biological and physical sciences to dental research is not only a fruitful source of ideas but an essential discipline. Too often, dental research proceeds along its own lines and falls into avoidable error through failure to keep in touch with the basic sciences. The separation of medicine and dentistry may be necessary for proper technical progress but is not always in the best interests of basic dental research.

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26. Seward, T.—Aust.J.Dent., 54:10, 1950.

POST-OPERATIVE RESPIRATORY INFECTION*

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The subject of post-operative respiratory infection receives insufficient attention from many dental surgeons. The term often applied to it, viz., "post-anaesthetic pneumonia" is in itself a misnomer. The condition is not due directly to anaesthesia and may occur where no general anaesthetic has been given at all. At the same time, dental surgeon and anaesthetist may well collaborate in its prevention, such collaboration being often more profitable than brilliant individual performance.

PATHOGENESIS.

Respiratory infection may follow the entry of foreign matter into the bronchial tree or it may arise independently. In either case, a similar sequence of pathological changes occurs, as follows:—

1. *Obstruction* of a bronchus, large or small, by a foreign body, by swelling of its epithelial lining or by the presence of tenacious mucus. Because of this obstruction, the group of alveoli arising from the bronchus in question becomes isolated from the external air.

2. *Atelectasis*, i.e., the absorption into the blood-stream of the air contained in the isolated alveoli, with resulting collapse of their walls.

3. *Infection* of the atelectatic area of lung by the organisms (pneumococci or, occasionally, streptococci) which normally inhabit the respiratory tract.

4. *Extension* of the infection, as a bronchitic or bronchopneumonic process radiating from the atelectatic area. This infection may subside or may proceed to the formation of a pulmonary abscess.

FOREIGN BODIES.

The foreign matter which may gain access to the bronchial tree in the course of a dental operation includes:—(a) teeth, or fragments of teeth, (b) blood or clot, (c) vomitus, (d) fluid anaesthetic, in the event of cross-connection of certain types of vaporizers.

The results will depend upon the size and infectivity of the foreign body. One large enough to occlude a stem-bronchus will produce rapid and widespread atelectasis, involving a whole lobe or lobes. One small enough to reach a secondary bronchus will produce atelectasis upon only a lobular scale. It will not have even this effect immediately, because lateral communications exist between groups of alveoli arising from the same bronchus: atelectasis will therefore not supervene until these communications become blocked by the eventual inflammatory reaction.

Dental substance is often of comparatively low infectivity, so that its inhalation may not be followed by symptoms for days or weeks, until inflammatory swelling of the bronchial epithelium takes place. This results in atelectasis and probably in the formation of an abscess. Blood, again, may be comparatively sterile, producing atelectasis only if a clot forms in a minor cronchus: it may, on the other hand, carry in virulent organisms and lead to prompt

*Read at the Twelfth Australian Dental Congress, Sydney, August, 1950.

pneumonic reaction. Vomitus, unless promptly and thoroughly aspirated, is likely to produce acute inflammation. It may even cause sudden death, not so much by drowning, it is said, as by reflex inhibition of the heart when an irritating fluid reaches the broncial tree. The inhalation of fluid anaesthetic will probably result in sudden death or in rapidly fatal haemorrhagic pulmonitis.

The entry of foreign matter into the lungs during dental operations is happily less common now than formerly. A series of cases of pulmonary abscess resulting from it was collected by Dr. H. R. Cash, of Melbourne, in 1933. In those days, when such a case reached a Public Hospital, the admitting officer was wont to ask:—"When did you have your teeth out, or was it your tonsils?" The present rarity of pulmonary abscess is attributable to three factors:—(a) limitation in the scope of operations attempted under nitrous oxide-oxygen given by the nasal route, (b) the corresponding increase in the use of endotracheal anaesthesia, and (c) the better understanding by dental surgeons of the advantages of pharyngeal packing and of tracheal aspiration.

The mere suspicion that foreign matter may have entered the bronchial tree is the indication for active treament. Blood or vomitus should be aspirated through a catheter passed down the endotracheal tube. When this catheter reaches the sensitive carina, the patient will cough and empty the contents of his bronchi into his trachea, whence they can be aspirated. Should the contamination be massive, as where copious vomiting has occurred, bronchoscopy must be performed. This procedure is familiar to the modern professional anaesthetist. The after-care of such patients is described later in this paper.

Should a tooth or other solid body be suspected of having entered the trachea, planned action is required. The debris of the operation-theatre must be searched and all sputum or vomitus produced during the period of recovery from anaesthesia must be examined. If the foreign body be not found, radiography must be performed at the earliest opportunity. If the intruder can be localized, it must be removed by bronchoscopy. A small foreign body may be masked, however, by the normal shadows at the root of the lung and so escape detection. Further, artificial teeth may be radio-translucent. They have been, according to Dr. R. H. Orton, sometimes found in the lungs of patients admitted to the Thoracic Unit at the Alfred Hospital. Hence the absence of positive radiographic findings does not mean that a foreign body may not have been inhaled. The patient must, therefore, be told to report any cough or febrile disturbance which may develop during the next six weeks. Should any develop, radiography should be repeated and exploratory bronchoscopy be performed. The foreign body may, however, by now form the centre of a pulmonary abscess and defy removal at bronchoscopy. In this event, a thoracic surgeon must be consulted with a view to lobectomy. Accidents will happen and failure to prevent contamination of the bronchial tree at operation does not necessarily imply culpable negligence. The culpability would lie in failure to recognise the contamination and to initiate the requisite treatment.

Atelectasis.

A bronchus may become obstructed, without entry of a foreign body, from the following causes:—

1. *Direct obstruction* by tenacious mucous.

2. *Epithelial engorgement* resulting from an irritating anaesthetic vapour, from the presence of oxygen-lack during anaesthesia or from circulatory stasis consequent upon cardiac inefficiency.

3. *Oedema,* the result of oxygen-lack or of attempts to inhale against resistance, as where the valves of the anaesthesia apparatus are defective. Since the alveolar saccules and the pulmonary capillaries are lined each by a single layer of endothelium, it takes only very slight damage to the capillary walls to produce oedema of the lungs. This, by occluding the lateral communications between groups of alveoli, favours the development of atelectasis.

4. *Deficient expansion* of the lungs in the post-operative period, the result of prolonged and unduly deep anaesthesia or of undue recumbency.

5. *Suppression of the cough-reflex* by excessive premedication or by unduly deep anaesthesia.

In all these cases, a group of alveoli (especially at the bases of the lungs) becomes isolated from the external air by a mucous plug or by swelling of the bronchial epithelium. In addition, it may be sodden with secretion which fails to drain away. Atelectatic collapse of these alveoli ensues and is followed by infection, the latter spreading outwards as a bronchitic or bronchopneumonic process.

Atelectasis may occur in an acute or a sub-acute form. The acute, known as "massive collapse of the lung," is comparatively rare, although most anaesthetists have encountered a case or two. Large bronchi are affected, the atelectasis being thus rapid and upon a lobar scale. The patient presents a picture of acute respiratory distress, his skin being cyanotic, or even gray by reason of secondary depression of the circulation. The affected side of his chest obviously fails to ventilate. His condition represents a respiratory emergency, everything depending upon its recognition and prompt treatment. The latter consists in immediate bronchoscopy and aspiration of the plug of mucous or clot which is obstructing the bronchus in question.

The sub-acute form is more usual. Since only a minor bronchus is affected, the resulting atelectasis is slower in onset and upon only a lobular scale. The patient, in the hours following operation, is less well than he ought to be. Within 24-36 hours, his respiratory rate increases; his temperature rises to perhaps 101°F. and he develops a cough. His sputum becomes thick, purulent and "oyster-like." He may, in a burst of coughing, expel the occlusive plug from his bronchial tree and recover with dramatic speed. More usually, his collapsed alveoli become infected and he develops a bronchopneumonia, which subsides gradually in about a week. It does not, in these days of chemotherapy, often run an unfavourable course or result in the formation of an abscess, but it may leave a residual bronchiectasis.

Much can be done to prevent the occurrence of atelectasis. Smoking should be limited to a reasonable amount in the days preceding operation. Pulmonary secretion, if any, can be diminished by breathing exercises, postural coughing and inhalations of nebulized penicillin. Heavy premedication is undesirable before oral operations, it being important to restore promptly the ability to swallow, to cough and to move about in bed. Irritating anaesthetic vapours should be avoided in presence of gross respiratory disease, although the choice

of a non-irritating agent is but a single and comparatively minor factor in prophylaxis. Deep anaesthesia of unnecessary duration should be avoided. Oxygen-lack, accumulation of carbon dioxide and respiratory resistance must be eschewed during transportation and in the operating-theatre. At operation, full use should be made of pharyngeal packing and aspiration. The endotracheal tube, it should be remembered, is meant to provide an airway and not to keep foreign matter out of the bronchial tree: the latter function belongs to the packing, which must therefore be efficient and must be renewed whenever displaced or saturated. Should blood or secretion be present in the bronchial tree at the end of operation, the trachea must be aspirated in the way already described. This principle applies even to minor dental operations performed under nitrous oxide-oxygen given by the nasal route. Should blood have penetrated the mouth-pack and invaded the hypopharynx, the anaesthetist should, at the end of the administration, intubate the trachea "blindly" through the nose and perform aspiration.

When the endotracheal tube is finally withdrawn the patient should be placed on his side, with his head low. He should be kept in this position, both on the trolley and in bed, until he has regained consciousness. In the words of Professor A. B. P. Amies, the aspirator should be the first instrument to be set out on the patient's arrival in the operating-theatre and the last to be cleared away on his departure.

The final and most essential step in prophylaxis is post-operative "stir-up" treatment, introduced by R. M. Waters. The nursing sister, at hourly intervals, urges the patient to breathe deeply, to cough and to breathe deeply again. Secretion is thus removed from the lungs, the alveoli are expanded and atelectasis is prevented. Experience shows that, in those wards in which the "stir-up" is best understood by the medical and nursing staffs, the incidence of respiratory sequelae is least. Post-operative inhalations of carbon dioxide were in great favour a decade ago, but are now held to be ineffective in comparison with the lung-expansion which results from the patient's voluntary efforts.

Should atelectasis occur in spite of these measures, it is important that it be overcome before the collapsed alveoli become infected. To this end, the "stir-up" is intensified: liquefying expectorants and sulphonamides are given. Should improvement not occur within 24 hours, more active treatment is needed. This is most likely to be the case where the sputum is either copious or tenacious, or where a definitely non-ventilating area can be detected on examination of the lungs. The treatment consists of the "tracheobronchial toilet" of Waters. The nose and throat are cocainized and an endotracheal tube is passed "blindly" through the nose into the glottis, and the trachea is aspirated. The procedure is within the capacity of any anaesthetist and its efficacy depends, not so much upon the aspiration, as upon the very active coughing which it induces. Should it fail to overcome the atelectasis, penicillin should be given and arrangements be made for bronchoscopy. The latter is a severe ordeal for a patient recovering from operation, but it is preferable to being left with an infected and untreated atelectasis.

CONCLUSION.

Post-operative respiratory infection was formerly common. Ross, in 1923, put its incidence at 4 per cent. after anaesthesia with ether. It is now far

lower, because atelectasis is better understood and wider use is being made of the endotracheal tube, the pharyngeal pack and the aspirator. The present writer has consulted the personal records of 1317 dental cases in which "follow-up" was adequate. Of these, 638 were minor operations carried out under nitrous oxide-oxygen given by the nasal route. The only respiratory sequel to be recorded was the "common cold." The other 679 operations were major ones, performed in hospital under endotracheal anaesthesis. Respiratory infection supervened in three cases, the incidence being 0.44 per cent. One of the patients suffered exacerbation of an undiagnosed tuberculous infection; another, exacerbation of pre-existing bronchitis. The third, a healthy subject, contracted bronchitis which was unexplained and should probably not have been allowed to occur.

It will be seen that the incidence of respiratory infection after dental operations is low. The patients concerned are usually free from pre-existing disease of the lungs. They are not exposed to the diaphragmatic paresis and resulting pulmonary sub-ventilation which follow abdominal operations, nor to the prolonged immobility which may follow orthopaedic surgery. Prevention of respiratory infection is, in them, largely a matter of defence of the bronchial tree against contamination by blood, pus or dental fragments. This defence is a mechanical problem, to which modern anaesthetic and surgical technique provides an adequate solution.

A striking feature of post-operative respiratory infection is the difference in prognosis now, as compared with that in the period before the Second World War. The writer has consulted personal records of 5,274 cases of the pre-war period, in which "follow-up" was adequate. They included operations of all types, under every form of general anaesthesia. The over-all incidence of respiratory infection was 0.5 per cent, a figure reasonably satisfactory. But, of the 26 patients who contracted such infection, seven (or more than one quarter) died of it. This result seems appalling today when the prognosis has been revolutionized by "stir-up" treatment, tracheobronchial toilet, the sulphonamides and the antibiotics. The present favourable outlook must not, however, engender a casual attitude towards post-operative respiratory infection. The latter is still potentially dangerous and carries a risk of permanent invalidity. It is also usually preventible.

FUNDAMENTAL PRINCIPLES INVOLVED IN PARTIAL DENTURE DESIGN WITH SPECIAL REFERENCE TO EQUALIZATION OF TOOTH AND TISSUE SUPPORT*

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Great advances have been made in the prosthetic phase of dentistry in the last three decades. However, complete denture prosthesis has been distinctly in the spotlight. Removable partial denture development seems to have suffered, with efforts being focussed on the rapid improvements in complete denture service.

Fewer contributions have been made to removable partial denture progress for various reasons. Some of these may be listed as:—

1. The difficulty of designing removable partials, since to the average general practitioner it has often seemed so much simpler to extract the teeth and supply a complete denture.
2. The impossibility of providing a set design and plan of procedure to apply to all the varied cases, as can be done for complete dentures.
3. The general feeling among dentists, as well as among patients, that removable partial dentures, at best, are temporary restorations—merely stepping-stones to the edentulous state.

At any rate, regardless of where the blame is placed, the history of removable partials records far too many failures. And, unfortunately, these undesirable end results often come about through the simple neglect of, or the heedless omission of, one or more seemingly unimportant items in the plan of procedure. As a result, the removable partial denture phase of dentistry suffers the shameful distinction of being the most neglected and most abused of all dentistry's subdivisions.

At the outset, for better interpretation, we should have a clear-cut definition for "partial denture." Inasmuch as a "complete artificial denture" is one which supplies, by artificial means, the full complement of missing teeth (excepting the 3rd molars) and adjacent structures in an edentulous arch, it seems feasible that a "partial denture" may be defined as that form of prosthesis which supplies one or more artificial teeth and contiguous structures in a partially edentulous arch. A partial denture, then, may be a fixed denture, cemented to place (so-called bridge); or it may be the removable type, taken out at will by the patient. It follows, therefore, that a removable partial, as referred to in this treatise, may derive its fixation from either internal (slotted) or external (clasp) attachments; and, for the sake of conciseness, this type of appliance will usually hereinafter be called a "partial denture."

It is extremely regrettable that this phase of dental health service has achieved such an unenviable reputation. Some of the sins of omission leading

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up to the alleged deplorable status of partial denture service are: lack of a careful diagnosis, supported by accurate study models and well-defined radiographs; failure of the dentist at least to survey and design cases personally before having them fabricated by the technician; a neglect of the application of the broad fundamental principles of favourable leverage in design; improper distribution and reduction of destructive forces, to convert them for physiological stimulation; an indifference to the absolute necessity for centric relationship; an almost wholesale dispensing with the preparations of the mouth, in clasp partial operations, before making final impressions; an ignorance of that "indispensable denture movement" in function; a luke-warm attitude towards the importance of a balanced occlusion; and the careless assumption that, without any instruction, the patient taking delivery of his partial denture knows fully how to use and care for it.

The step in clasp partial procedures most often neglected or deleted altogether is the "preparation of the mouth, or alterations, before making final impressions." Under this heading, the following fall:—

The making of full crowns to restore posterior abutments which are already carious at the gingival.

The correcting by grinding, or with restorations, of teeth which are leaning or over-contoured.

The providing of an occlusal embrasure space, either by judicious stoning of enamel only, or by precious metal fillings, where a clasp must be used on the side of the arch presenting a tight, ideal occlusion.

The slight "cupping out" of incisal enamel corners for the reception of an incisal embrasure hook or rest for direct retention.

The preparing of rest areas with positive seats for incisal and occlusal stops, either in the tooth structure or in metallic restorations.

The reducing by surgery of interfering ridge convexities and bulbous tuberosities.

The balancing of the natural occlusion, so that the artificial occlusion can be harmonised with it.

The placing of complete metal crowns with proper contour for clasping on posterior teeth whose surfaces converge occlusally.

The proper contouring, by discing, of the mesial and the distal proximal enamel aspects of any anterior tooth which is to accommodate a mesio-distal clasp.

The crowning or inlaying of teeth with excessive long-axis inclinations, to provide abutment tooth alignment in harmony with other teeth.

The reducing surgically of remaining occlusal gum tissue or of hypertrophied or bulging gingival tissue about teeth to be clasped.

The removing of a torus mandibularis to make room for a lingual bar.

Finally, a thorough prophylaxis.

In partial denture construction, at least two of the above-named requisites are *always necessary*: the providing of *properly shaped support or stop areas* and the *meticulous cleansing* of the remaining teeth. All surgery, extractions, elimination of periodontal pockets, and fixed restorative pro-

cedures, when necessary, should be completed before the making of final impressions.

To enhance self-assurance and to secure the confidence of the patient, it cannot be over-emphasized that a most careful diagnosis is a pre-requisite to the contemplated treatment—to *any* form of treatment—and the results ultimately obtained will directly reflect that meticulous diagnosis. Many cases end in the discard, merely because of our not having carefully measured the problem.

In all complex cases, to size up the problem accurately, three things are necessary: study models mounted on an adjustable articulator, radiographs of the case under consideration, and the patient. We cannot well get along with any one or two—we must have, at hand, all three. From the mounted casts, we study the mechanics, note the comparative sizes of the arches, interferences in protrusive and lateral shifts, clearances for rests, possibilities of clasping, probable fulcrum lines, and lengths of leverages. Radiographs aid us in studying the health of elements which will give support in function, as well as enable us to note diseased conditions. Xrays at one time encourage us by the excellent conditions presented; at other times most discouraging facts are brought to light—both conditions revealed having a distinct bearing on our plan of procedure. The patient, by being present, obviously lends us the most assistance. We must note his age, general health, firmness of remaining teeth, and tone of oral tissues; also make enquiry as to the success of previous restorations and the possibility of his suffering from such diseases as tuberculosis and diabetes. Such a procedure leads us in a meticulous, scientific way towards the attainment of our restorative goal. A thorough diagnosis constitutes a careful inspection of our proposed building site.

In a word, our thorough consideration of any case will determine what type and design of restoration will best serve the patient in the preservation and perpetuation of remaining local structures and in promoting general health. This is our objective.

A diagnosis having been made, utilizing *all* obtainable factors to aid us, we next proceed to the prognosis, where a word of caution is in order. We who render this type of service must constantly remind ourselves that, in our enthusiasm, we must not promise the impossible. The masticatory apparatus is broken down and crippled when it comes to us—we must guard against a prognosis of results equal to, or better than, normal. If the problems to be met in design and treatment were wholly mechanical, a complete restoration of function might be predicted in chosen cases, but the mechanical phases must be subordinated to the biologic. The success of a case is largely dependent upon biologic response.

It must, further, be remembered that favourable response of the living tissues over a period of time depends upon our recognition of the necessity for slight denture movement while in function. If we anticipate this movement, we can better regulate it. This functional denture motion must be accepted as a requirement, then controlled by our design, and finally converted to favourable physiologic stimulation instead of trauma. Every application of a mechanical principle must be made with special reference to the ability

of the various supporting teeth and more yielding tissues to accept the movement and stresses imposed on them. Favourable forces and physiologic stimulation — an individual problem with each patient — will enable these structures to bear up indefinitely.

Proper design and adequate support, therefore, are of prime importance—such proper design *creating* advantages by keeping unseating, hard stress leverages short and all controlling leverages long; and broad support providing normal functional stimulation of all sustaining elements of tooth and tissue, instead of imposing trauma upon them. Such is the ideal—not always possible of attainment!

One would be relatively safe in venturing the assertion that all leading men in the field of partial denture pursuits are quite in agreement on the essentials mentioned up to this point. However, in the consideration of what constitutes correct design and adequate support for free-end based cases, involving tooth support and engagement combined with ridge support, the literature reveals a long-standing and perpetual controversy among the partial denture prosthetists. No suitable one-piece impression material has ever been discovered or synthesized to produce proper functional displacement of the soft tissues in relation to the dense, hard, relatively stable teeth. Hence the contention over what constitutes the best way to utilize and equalize ridge support along with tooth support.

The published articles on the subject of partial dentures roughly classify the authors into three groups:—

i. One school believes that ridge and tooth supports can best be equalized by the use of stressbreakers or resilient equalizers.

ii. Another insists upon bringing about this equalization of ridge and tooth supports by physiologic basing—bases with functional, displaced tissue form. This is accomplished by a pressure impression or by rebasing the case under biting stress.

iii. The third school upholds the idea of extensive stress distribution for the purpose of stress reduction at any one point.

Many scholarly and highly scientific articles, by outstanding members of the dental profession, appear in support of each group. All treatises on partial dentures which were available have been reviewed.

School of Thought Favouring Stressbreakers.

One group of thinkers on the question of how best to equalize stresses, where a combination of tooth and soft tissue supports exists, which will be called the first group, emphasizes the immovability and non-resiliency of teeth in an apical direction and points out that the resiliency of the periodontal membrane is not at all comparable to the greater resiliency and displaceability of the ridge mucosa. They, therefore, condemn the rigid connection of direct retainers to the base and insist on some type of stressbreaker or stress-equalizer. Here, immediately, the biological and physiological phases become linked up with the mechanical.

Requirements for stressbroken cases:

Clasps or frictional attachments.

Some form of stressbreakers.

A minimum of tooth engagement.

Bases of ordinary anatomic form on ridge surface.

Possible advantages:

Resiliency of stressbreaker added to that of periodontal membrane makes the sum of the two comparable to the resiliency of mucosa.

Strikes a stress balance in division of duties between abutments and ridges.

Prevents bone resorption about abutments, as tipping strain is eliminated.

Intermittent pressure of bases massages mucosa, providing physiological stimulation resulting in thickening of cortical layer of bone and soft tissue cell proliferation.

Favourable to abutment teeth as stresses are reduced and trauma prevented.

On account of physiological massage, stimulation prevents bone resorption, and rebasing is minimized.

Because of relative passivity, denture feels comfortable from moment of insertion.

Possible disadvantages:

Construction of appliance more difficult and complex, more costly, more fragile, and more servicing necessary.

If stressbreaker is too weak or too movable, rapid absorption of bone and consequent settling will result—as allowed by a clasp without a rest.

Restoration often quite bulky and heavy.

Resilient types of stressbreakers frequently pinch the tongue and other lingual tissues.

If bone absorption results, abutment-base relation changes, requiring frequent rebasing.

Some forms of equalizers allow strangulation of tissue distal to abutments, causing periodontal disease.

Restoration being movable does not well allow for indirect retention.

Prosthesis is not stabilized against lateral thrusts.

In support of the broken stress principle, Meyer says: "In the act of mastication, the denture is forced against the tissues without any apparent stress on the supporting teeth. When the pressure is released . . . . the stressbreakers automatically allow the denture to reassume its rest position in relation to the tissues. This consecutive pressure, followed by relaxation, massages the gum tissues and should tend to keep them in a healthier state."

Neurohr favours stressbreakers by saying: "It is a mistake to take impressions of ridge areas under pressure. . . . When such sustained pressure is incorporated in an appliance, we invite periodontal lesions and abnormal recession of the alveolar process, because of the trauma incurred. Impressions should be taken without compression with the tissues in the passive state.

The restoration, however, should be so designed that . . . it will, when the pressure of mastication is brought to bear upon it (through spring action), distribute this force evenly over the largest tolerable area possible."

Jones adds to this: "If these devices (stressbreakers) are correctly made, the operator will not only be surprised but will also be gratified to see how little resorption takes place beneath saddles."

McLean says: "In no case should rigid attachments, whether precision or non-precision, be used without means for equalization of the resilient and non-resilient supports. Equalization of the resilient and non-resilient supports is accomplished by interposing between the supporting teeth and the movable denture either resilient metal or movable joints."

Cody brings out: "Intermittent pressures on saddle areas and absence of continued pressure causes the rebuilding of bone rather than absorption . . . broken stress on extension saddle cases is a most desirable preventive measure even for the normal case."

Van Minden writes: "We must see to it (by breaking stress) that the abutments shall bear only the vertical and lateral stresses that properly should fall on them during mastication, . . . finally, the case should resume its normal position when relieved from masticatory pressure. As a result of the equitable distribution of the masticatory stress over the entire alveolar ridge (through stressbreaking action) the need for rebasing has been reduced to a minimum, and frequently has been entirely eliminated."

School of Thought Favouring Physiologic or Functional Basing.

A second group of workers agrees in emphasizing the relative immobility of teeth in an apical direction but denies the necessity of stressbreakers and insists that combination and equalization of base and tooth support can be accomplished by some form of "Physiologic Basing." This group favours a few relatively mobile direct retainers, to be used for *only limited retention*. Functional displacement of the mucosa must be secured either in the impression-making by pressurized recording, or by means of a "pressure rebase" which will record the "functional form" of the tissues as contrasted with the static "anatomic form."

Requirements for physiologically based cases:

Tissue side of bases presents functional form.

Artificial teeth make slightly premature contact.

Occlusal rests or attachments are just unseated till mucosa is displaced to functional form.

Direct retainers are freely movable.

Minimum of direct retainers, for retention only.

Advantages which should accrue:

Simplicity of design and construction results in light weight, small bulk and little servicing.

Lightness of clasp contact (or freely movable frictional attachments) is kind to abutment teeth.

Mucosa and ridge really bear their part of masticatory burden.

Tissues are physiologically stimulated (massaged), resulting in normal function and repair.

Necessity for rebasing eliminated on account of cell proliferation through physiologic massage.

Disadvantages which may result:

On account of free-moving and minimum number of direct retainers, denture is not well stabilized, and soft tissues must resist lateral thrusts.

Also—

Uncomfortable at first because of high occlusal contacts.

Over-compression of tissue, in securing its functional displacement, will result in rapid resorption and need for rebasing with many types of mucosa.

Movement of restoration results in sense of insecurity.

Indirect retention inefficient on account of vertical denture movement.

Remaining teeth do not perform their share of the work towards stress support and stabilization.

In support of the principle of physiologic basing, Applegate writes: "An appliance . . . should be able to move with the tissue which supports it. . . . A clasp should provide only sufficient retention to resist dislodgment by the adhesion of foods . . . peripheral muscular action . . . or gravity. . . . An impression material is required which will effect partial displacement in the softer areas. . . . When stress is applied, the fluid content of the subjacent tissues will be slightly displaced. After the load is released, a slight tissue rebound occurs. Increase in blood flow results. . . . This physiologic stimulation maintains a healthy condition and counteracts resorptive processes."

Donovan says: "Rebasing lower dentures is usually advisable either by the impression method or after the denture has been completed. . . . It is a good plan to arrange the (clasp) lug so that, when the denture is inserted, there is a slight distance free. . . . The saddles, of course, in all these cases must do the major portion of the work."

McNeil adds: "In most instances, tissue-borne cases should be taken under pressure."

Girardot states: "The saddles, to be most comfortable, should conform to the functional shape of the tissues, rather than the anatomic shape. This is assured by the special wax rebasing technique. . . . Occlude under pressure, which produces a functional impression."

The Pasadena Prosthetic Study Club reports: "There should be a minimum number of clasps on a case for retention, and a minimum of contact area on a tooth. There should be sufficient grasp to retain the denture, but also . . . allow the denture to move on compressible tissues and permit a certain amount of independent movement of the saddle."

Jordan says: "An accurate copy of the teeth is essential in all cases, but the soft tissues that may be utilized for any portion of the denture foundation should be recorded in a state of functional displacement. If compression of

the mucosa is not accomplished during impression-making, rebasing should be done either during the procedure or after the denture has been made. . . . It is only after the resiliency has been overcome and the soft tissues have been compressed to a state where they offer resistance . . . that they become of proper service to the prosthesis."

School of Thought Favouring Broad Stress Distribution for Stress Reduction.

A third group believes that excessive trauma to both ridges and teeth can be prevented by stress distribution over as many teeth as it may be advisable to engage with rests and rest-supported clasps. In this way, stresses are reduced on any one tooth or ridge, as all collectively bear the load. Four teeth carrying a load may be physiologically stimulated to robust health, while two teeth carrying the same load may be overworked and traumatized, and become loose. Both of the previously mentioned groups engage as few teeth as possible with direct retainers, and these for retention only. The same groups attach little significance or importance to the horizontal shifts of a denture, which lateral movements are strongly emphasized as destructive by the third group members, who recommend multiple tooth engagement by clasps and extra rests chiefly to prevent those movements. Why require two teeth to carry all of a given burden when four or more may be utilized?

Requirements for "distributed stress" cases:

Cast or rigid wrought direct retainers (internal or external).
Positive lug seats.
All-rigid, non-flexible framework.
Multiple rests and direct retainers—as many as feasible.
Indirect retainers to add stability, where practicable.
Well adapted, broad coverage bases.

Advantages from this type of design:

Functional stresses are limited and distributed, protective influence exerted, over-stimulation prevented.

Teeth are immobilized, allowing for tissue regeneration.

Teeth bear part of stresses, and base area its part, each aiding the other. If no denture present, remaining teeth would do all the work.

Dentures function efficiently for a long time without loss of teeth or rebasing, since no stress-supporting element is over-stimulated or traumatized.

Little servicing on account of rigid construction eliminating hinge and movable devices.

Cases are well stabilized against teeth to resist lateral thrusts.

Cases permit, and usually provide, excellent indirect retention.

Ridge tissues sufficiently stimulated to promote health, but trauma is avoided on account of assistance from remaining teeth.

Disadvantages which may result:

Additional supports and contacts on teeth sometimes irritating to tongue.
Because of multiple contacts, cases may be more conducive to caries.

In support of stress distribution, Woodworth has this to say: (This design) "distributes the masticatory stress over as many natural teeth as desired, thereby taking the stress off or relieving the abutment teeth."

Smith says: "Contact against remaining teeth is the chief means of stabilization in tooth-borne cases and of considerable importance in tissue-borne cases."

Roach writes: "The only occasions for the use of so-called stressbreakers are those cases where anchor teeth are badly off parallel. Their employment otherwise is an apology for inaccuracy of construction."

De Van states: (For stability) "other teeth (besides abutments) in the arch should be utilized through occlusal rests in the lingual embrasures. Such teeth could be designated as 'auxiliary abutments.'"

Levin lends his support with: "Profound thought must be given to minimising occlusal and lateral stresses and to the broadest possible distribution of these stresses."

Addison agrees that: "We know that the more teeth included in the construction of the restoration, either with multiple attachments or with multiple united abutment pieces, the better the division of the stresses among the remaining teeth."

Steffel upholds the school by saying: "The denture must have definite tooth support by multiple clasps and occlusal rests. The greater the number of rests, the better the stress distribution."

Schott writes: "The devotees of stressbreakers on partial restorations . . . . . . argue for the massaging effect . . . . . . it seems to me merely a transfer of trauma. . . . . . . I have seen few (stress-broken cases) that will last a great length of time without remaking or readjusting to prevent abnormal pull and stress on attachment teeth as the case settles."

Schuyler insists: "Our problem as denture prosthetists is the reduction and distribution of stress in an effort to prevent over-stimulation and destruction of the tissues supporting our appliance . . . . . . Unnecessary saddle mobility endangers the supporting tissues. Therefore we must, whenever possible, limit and distribute functional stresses, thereby endeavouring to keep stimulation within the bounds of tissue tolerance.

"Stressbreakers are seldom indicated, and never those which permit all the occlusal stress to be placed on the saddle-supporting tissue, or which permit excessive movement of the denture base. The most nearly permanent results are secured by a distribution of force, and such distribution is impossible with connectors of this type . . . . . . The dentist need not worry about the possibility of obtaining the limited stimulation essential to tissue health. His problem is to avoid . . . . . . overstimulation."

Elliott sums up the thinking by: "The majority of partial dentures can be planned in a simple manner and still render as satisfactory service as many of the more complex designs requiring the use of precision-type retainers and stressbreakers. To be able to design partial dentures, so that all the complex stresses that are induced during function of the partial denture and its supporting structures could be equalized, and to keep these stresses within physiological limits, would be ideal."

In summarizing, let it be emphasized that a partial denture, properly designed and meticulously constructed, dignifies the partially edentulous arch into which it is placed; one which is an abortion of accepted principles wrecks it. Therefore, a further discussion of the relative merits of the three types of treatment for the partially edentulous arch, and a full, clear elaboration on just when and where to apply best the design of each school of thought can well constitute sufficient material for additional extensive research. Despite the fact that there are numerous superb materials and techniques for the fabrication of partials, and as many different possible designs for a given case, nothing can supercede good judgment, coupled with a knowledge of basic principles. Many men, as dentists, use "snap judgment" in the application of these fundamental principles; or, even worse, they all too often send cases to a remotely located laboratory which makes up a "run-of-mill" partial based solely on mechanics. The results are devastating to tooth, soft tissue, and osseous structures.

In your acceptance of the efforts put forth in assembling material and your evaluation of the opposing views presented, please let it be hinted that our minds must be like a parachute—functioning only when open. Therefore it is not a compromise with evil, nor is it the shunning of a moral responsibility to our patients, to say that each school—that favouring stressbreakers, that advocating physiological basing, and that supporting extensive stress distribution—has some merits, when the particular denture design belonging there is given the correct clinical application. The dental laboratory technician does not possess sufficient data to do this. It is decided upon by painstaking diagnosis. Only the dentist, who studies the case with the radiographs, study models, and the patient himself present, can arrive at the correct solution. We must consider the characteristics of the tissues along with the mechanics—in that way measure our problem—and then, and not till then, proceed with the mechanical and structural phases. In a general way, it may be stated that a partial denture should be constructed as simply as possible, consistent with function. Pendleton has so conclusively stated that "materials and methods avail but little when the structural characteristics of the tissues are ignored; and that the biologic factors are the directing influences or controls that determine the virtue of the procedures employed in clinical practice."

A METHOD OF TREATING PROTRUSION OF THE UPPER ARCH IN ANGLE, CLASS II DIV. I MALOCCLUSION*

B. L. ROSENSTENGEL, D.D.S.

This contribution outlines a method of treating that type of Class II, Div. I malocclusion in which the lower jaw is normal in relation to the dento-facial features, but the upper jaw is in protrusion, as described by Dr. Case in his text-book, "Dental Orthopedia and Treatment of Cleft Palate."

To distinguish the different types, Case, you will remember, relies on the shape of the mento-labial sulcus, and the position of the lower lip in relation to the chin which latter, he maintains, is in normal dento-facial relation in all types.

Thus, if the mento-labial sulcus presents a definite V-shape and the lower lip is retruded in relation to the chin, retrusion of the lower jaw is indicated, whereas if the sulcus presents its aesthetic shallow concave outline, and the lower lip is directly above or slightly forward of the chin, while the upper lip is decidedly protruded, the features indicate an upper protrusion (Fig. 1).

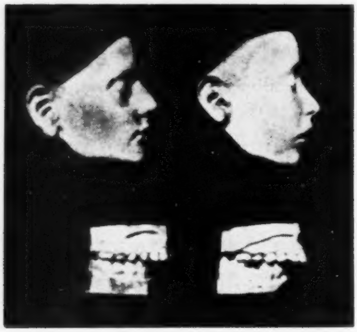

Fig. 1.—Different profiles in Angle's Class II, Division I malocclusion from cases (dental orthopedia and treatment of cleft palate).

The type to which any case belongs can be further confirmed by applying Professor Simon's "law of the cuspids." (Fig. 2.)

To correct the anomaly, the question is whether to alter the jaw relations by moving all the upper teeth posteriorly, or to institute normal breathing and a masticating occlusion by removing a unit from one or both sides of the upper jaw, according to whether the case is a Division or Sub-division, and retracting all teeth anterior to the space or spaces thus created. The author agrees with Case that the latter method of treatment should be adopted.

*Presented at the Twelfth Australian Dental Congress, Sydney, August, 1950.

If the extent of the protrusion is more than half a tooth the first premolar is removed, but if it is not more than half a tooth, remove the second premolar.

Fig. 2.—The application of Simon's "law of the cuspids" (from McCoy—"Applied Orthodontia").

The plan of treatment then is to retract first the cuspids only and later, the incisors.

This not only provides a less conspicuous appliance for half the period of treatment, but also allows lip pressure to exert a retractive force on the incisors. Thus it has been found that in almost every case treated, extensive retractive movement of these teeth takes place without the application of an appliance to them.

A period of three or four weeks is allowed to lapse after the premolar has been removed before the appliance to retract the cuspid bodily is allowed to operate. This appliance consists of two bands and a guide wire. One band is attached to the molar and the other to the cuspid. On the molar band is soldered a vertical tube and a vertical hook which opens towards the occlusal. In addition, a horizontal hook is soldered to the molar tube. On the cuspid band is soldered horizontally a long bearing round tube with gauge 19 bore. The guide wire is constructed of gauge 21 (.028) round stainless steel wire. Its posterior end is shaped to fit into the molar tube and inside the hook, the free end of which can be bent over the wire to lock it in position. The anterior end of the guide wire is fitted into the tube on the cuspid band. Where the wire extends forward beyond the tube it is given a bend in towards the teeth so

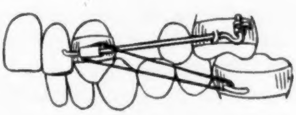

Fig. 3.—Appliance for the retraction of cuspids.

that the soft tissues of the cheek will not be irritated by that portion of it which projects anteriorly to the tube on the cuspid. To facilitate making this bend, the wire is annealed. (Fig. 3.)

Movement of the cuspid is effected by the use of intermaxillary elastic pressure, and in regard to this it is opportune to advise here that retraction of the cuspid should not be attempted by applying the pressure from the molar in the same jaw (unless it is desired to obtain a mesial movement of that tooth), as such an application of pressure usually tends to move the molar and 2nd premolar mesially instead of moving the cuspid distally.

The purpose of the horizontal tube on the cuspid is to ensure that the tooth will be retracted bodily and not merely tilted, and in order to reduce friction between the guide wire and horizontal tube it is important to remember that the bore of the tube should be at least one, and preferably two gauges larger than that of the guide wire so that a slight looseness of the wire within the tube can be felt when the wire is jiggled to and fro with tweezers.

The anchorage for the application of the intermaxillary pressure must be supplied by the whole of the opposite jaw rather than by an individual tooth, such as the molar. This is accomplished by the use of either the fixed lingual arch appliance, in which a gauge 17 or 18 wire is shaped to contact the lingual surfaces of the teeth and their gingival margins, and is then soldered to bands on the first molars. (Fig. 4.)

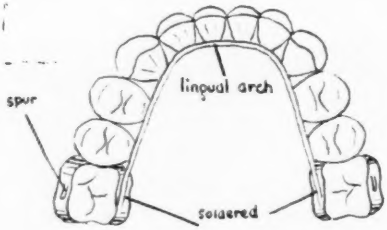

Fig. 4.—A fixed lower arch appliance.

Another method is known as the labial arch technique, in which bands are employed on the six anterior teeth in addition to those on the molars.

Where there is crowding of the lower teeth, the fixed lingual arch appliance is not indicated. Personally, the type preferred in such instances is the Angle Edgewise appliance, actuated by spiral spring pressure. This type of pressure is especially useful in those cases where the premolars are semi-impacted. (Fig. 5.)

At the end of a period of four weeks, the rubber ligature is attached from the hook on the lower molar band to the free end of the guide wire where it projects anteriorly from the tube on the cuspid band. The size of rubber ligature recommended for this purpose is the medium or large, No. 5 or 6, and the patient is shown how to apply them and is given a supply of ligatures so that they can be changed every four days. The patient must also be instructed that the ligatures must be worn consistently and removed only during meal-times, as it is important that the pressure should be applied and maintained persistently. Disregard of this instruction by the patient has been responsible for failure of treatment in a number of cases.

The condition is reviewed about once a fortnight, and the guide wire is carefully examined to see that it has free play in the cuspid tube, since during treatment a food film tends to form on the outside of the wire and on the inside of the tube. This prevents free movement of the tube along the guide wire.

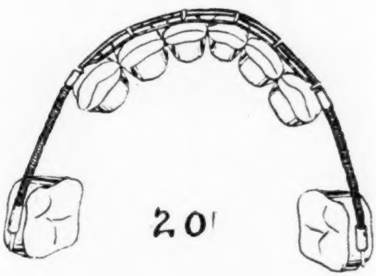

Fig. 5.—The Angle Edgewise appliance.

As the case proceeds, and retraction of the cuspid takes place, the position may occur where, although the cuspid is practically in its correct mesio-distal relation with the lowers, there is still more space than required between it and the second premolar, or between the first premolar and molar, if the second premolar has been removed.

This must now be attended to, since the aim of treatment is to close entirely the space created by the removal of the premolar. With this end in view, therefore, a smaller size of rubber ligature is employed, and is engaged from the upper molar instead of from the lower one. As the pressure will thus be exerted from a point in the same jaw, it will have the effect of moving the upper molar and premolar, or molar, mesially. Incidentally, it will not be necessary to remove the ligature at meal-times.

RETENTION.

When the cuspid has been sufficiently retracted, it is retained by soldering a lingual retaining wire from cuspid to molar (Fig. 6). In attending to this alteration of the appliance, the attachments on the molar band are replaced by a long bearing horizontal round tube with gauge 19 or 20 bore in readiness for the retraction of the incisors.

The appliance to retract the incisors consists of bands on both six-year molars and the four incisors. To each molar band is attached the horizontal tube just referred to and any suitable attachment is placed on the incisor bands. One simple type that has served the purpose well is the twin vertical hook attachment. It is simple to construct and operate, and allows easy play of the arch-wire whilst providing bodily movement of the teeth. Other suitable attachments are, of course, the Angle Edgewise, Ribbon Arch, Johnson twin wire, McCoy open tube, etc.

Where twin-hook or single-hook attachments are used on the incisor bands, a .022 round stainless steel archwire is engaged into the molar tubes and hooks

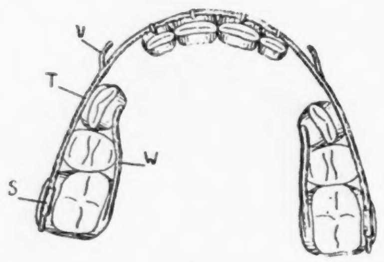

Fig. 6.—Appliance to retain the cuspids and retract the incisors.

on the incisors. The position of the cuspids is marked on the archwire, which is then removed from the mouth, so that the hooks, facing anteriorly, can be soldered to it at these points. The ends of the archwire are annealed at this stage. It is then replaced in position on the teeth, and the annealed ends, which project sufficiently far beyond the molar tubes to provide attachments for rubber ligatures, are bent upwards, to prevent dislodgement from either tube by the pull of the elastics (Fig. 7). Since the function of the tubes on the molar bands is only to stabilize the posterior ends of the archwire, their oversize bore does not matter and is intended to help the easier movement of wire within them.

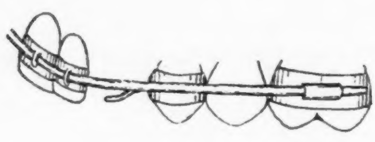

Fig. 7.—Buccal view of the appliance to retract the incisors.

Intermaxillary elastic pressure supplied the motive force for the retraction of the incisors also, at least for the first month or six weeks. Thereafter it can usually be of an intramaxillary nature. In fact, the use of intermaxillary pressure is a recommendation rather than an arbitrary statement.

There are, as mentioned earlier, cases in which a space remains to be closed after the cuspids have been sufficiently retracted, and in which intramaxillary pressure is thus indicated. Hence, in this respect, each individual case must be left to the discretion of the operator.

When the incisors have been retracted to their correct position, they are retained for two months by tightly ligating the archwire in position. The wire ligatures are engaged, of course, from the same points as the intramaxillary elastics, namely, from behind the free ends of the archwire to the hooks on it.

At the end of this period of retention, all appliances are removed, and the retention continued by means of a Hawley retaining plate. (Fig. 8.)

The patient is instructed to wear the plate continuously, except at meal times, for three months, and thereafter for the same period at night only. Treatment is then complete.

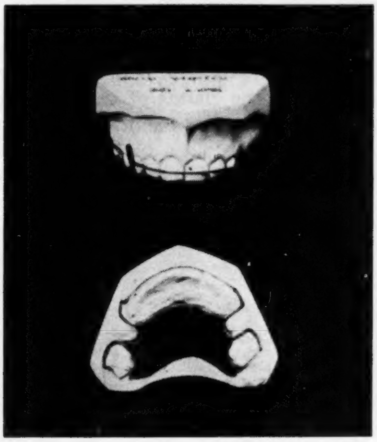

Fig. 8.—The Hawley retaining plate.

Of the hundreds of cases personally treated by this method, the percentage of relapses, mostly partial, has not been more than 3 per cent, in spite of the fact that in many instances instructions have not been adhered to in that the Hawley retainer has been worn very little, or not at all. In most instances where the relapse has been more or less complete, it was found that the habits contributing to the malocclusion, such as lip-biting, had been persisted in.

BALANCED OCCLUSION — A DISCUSSION ON CERTAIN OF ITS IMPORTANT ASPECTS*

F. TREBITSCH, B.D.S.

In 1949, two articles were published whose authors[1, 2] claimed that the use of adjustable articulators is not necessary. Many articles with similar claims were published while dentistry was developing as a science. However, these two articles are mentioned here, because a scientific society conferred prizes on the authors of these articles, apparently not being aware of the very important research evidence which refutes the claims of these two authors.

In order to make better known the results of research into balanced occlusion, it seemed to be appropriate to place before the members of the Congress the scientific evidence as compiled for the purpose of the general practitioner.

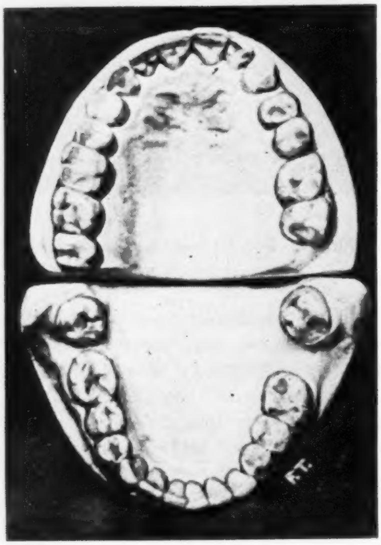

Fig. 1.—Facets of wear on all teeth signify balanced occlusion. Functionally perfect type according to Schroeder.

While this research work is not at all new, part of it is presented here for the first time in the English language.

During the past twenty years, the functional approach has won an ever-increasing number of followers in Periodontia and Orthodontics. This is quite

*Read at the Twelfth Australian Dental Congress, Sydney, August, 1950.

1. Craddock, F. W.—The accuracy and practical value of records of condyle path inclination: J.A.D.A., 38:697, 1949.
2. Kurth, L. E.—Mandibular movement and articulator occlusion: J.A.D.A., 39:37, 1949.

an understandable development and one has to agree with Maxwell[3] when he says, " . . . the fundamentals underlying occlusion, whatever they might be, should constitute the operative basis of all comprehensive dental procedures."

However, in Prosthetics, that branch of Dentistry which collected the fundamental experience and research now successfully applied in other branches, little progress has been made towards a functional approach in the average prosthetic work.

It is intended here to comment on certain well-established scientific facts which have a bearing on treatment-planning, as well as selection of methods and instruments. Knowledge of this evidence is helpful as some sort of yardstick in evaluating the various publications dealing with this controversial subject of balanced occlusion. Beyond that, the acceptance of this evidence and its transformation into techniques leads to a higher standard of the service given in daily practice.

We will attempt to present evidence without resorting to arguments or mathematics. Due to these self-imposed rather severe restrictions, and due to very limited time, we cannot help jumping across many gaps. However, later, it may be possible to clarify some of the issues not covered by this paper.

When we study models of a natural dentition, we find, occasionally, very marked facets of wear, the result of mastication (Fig. 1). While the mandible was working against the maxilla, the mode of movement was carved into the occluding surfaces by ordinary wear. We observe the facets in front teeth as well as in posteriors.

Models of such a natural dentition, cast in stone or metal, would allow the reproduction of the mandibular movements without any articulator, or any further recording of movement, just by sliding the facets of one model along the facets of the other.

An arrangement of occlusal contacts during functional ranges, as presented in these models, is what we call balanced occlusion. According to Schroeder[4], we have before us the functionally perfect type of the human dentition. It provides full masticatory efficiency; best distribution of masticatory stress on all periodontal membranes[5]; relief of the temporo-mandibular articulation of any disproportionate pressure[6]; thorough stimulation of circulation and cell life, in all supporting, moving, and controlling tissues of the masticatory organ, especially during growth; and, in conjunction with general health, static safety of the teeth as a result of a dynamic and biological equilibrium[7].

Such a dentition provides very valuable models for study, and it is a good policy to secure impressions, when a person with a functionally perfect norm passes through a dental practice.

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3. Maxwell, G. H.—A biological-mathematical formula for an ideal occlusion: J.A.D.A. and D.Cosm., 24:238, 1937.
4. Schroeder, H.—Lehrb. d. techn. Zahnheilkde., Vol. I, Berlin, Meusser, 1925.
5. Schroeder, H.—Ueber die Aufgaben der zahnaerztlichen Prothetik, Berlin, Meusser, 1929.
6. Trebitsch, F.—Effects of loss of vertical dimension in edentulous patients, D.J.Aust., 22:15, 1950.
7. Schroeder, H.—Zahnaerztliche Prothetik, eine Wissenschaft. Verhandl. d. 66. Versmmlg. Deutscher Zahnaerzte in Koeln, 1929, Berlin, Pusch, 1930.

If we were to insert a filling in the dentition shown in Figure 1, how would we have to shape the occlusal surface of this restoration? We would have to carve and model the filling in such a way that it will fit into the habitual movements indicated on the facets. If we built it up above the proper level, we would just be looking for trouble. If we built it below level, or omitted an important approximal contact, we might open a leak, where slowly, but steadily, the harmony and health of this dentition might seep away. Many cases of periodontal disease have started this way.

On the other hand, when we observe a dentition without balanced occlusion (Fig. 2), that means without contact of the posterior teeth during mandibular excursions, we have before us what has been named the functionally imperfect type. It is characterized by reduced masticatory efficiency. The masticatory stress is concentrated on a small number of teeth and periodontal membranes. The temporo-mandibular articulation is subjected to disproportionate pressure, and, therefore, may develop an osteo-arthritis in the meaning of Pommer[8] and Bauer[9]. Lack of proper function leads furthermore to preponderance of the hereditary anlage without being improved by stimulating wear and reactive adjustments. Static safety of the teeth is endangered by lack of a dynamic equilibrium; this dentition is, at least mechanically, predisposed to periodontal disease, and it is only a question of the constitutional factors, whether and when this disease will commence.

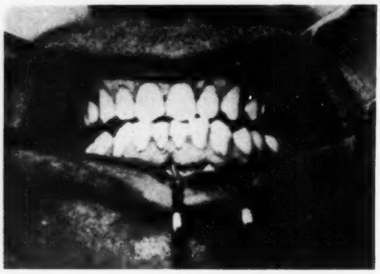

Fig. 2.—Facets of wear on front teeth only. Functionally imperfect type according to Schroeder.

Apart from this, the functionally imperfect type is the cause of many failures in dental practice, and such a failure will be shown later.

Bite rehabilitation tries to convert the functionally imperfect type into the functionally perfect type—the functional norm. This is one of the most comprehensive tasks of dentistry. Orthodontics and Periodontia are the branches of dentistry most concerned with the deep overbite of the functionally imperfect

8. Pommer, G.—Die chronisch deformierende Gelenksentzuendung (Arthritis deformans) vom Standpunkte der neuzeitlichen Forschung aus. Reprint. Sitzungsber, naturw.-med. Verein Innsbruck, Vol. 35, Innsbruck, Wagner, 1914.
9. Bauer, W.—Anatomische und mikroskopische Untersuchungen ueber das Kiefergelenk. Reprint. Zeitschr. f. Stom., 30:Nr. 18, 20, 21, 30, 1932.

type. Systematic spot-grinding is a frequently performed operation to give balanced occlusion to a natural dentition, for preventive or therapeutic reasons. However, in complex cases, inlay work, crown and bridge work, as well as prosthetics, have to play their part in the execution of a plan of treatment decided after thorough analysis and diagnosis.

Physiological, dental, medical and economical factors have to be considered. Nobody should tackle such a reconstruction of a masticatory organ unless he is trained, experienced and equipped to perform it. To plan a bite rehabilitation without paying proper regard to functional contact during mandibular excursions implies the planning of a mutilating operation.

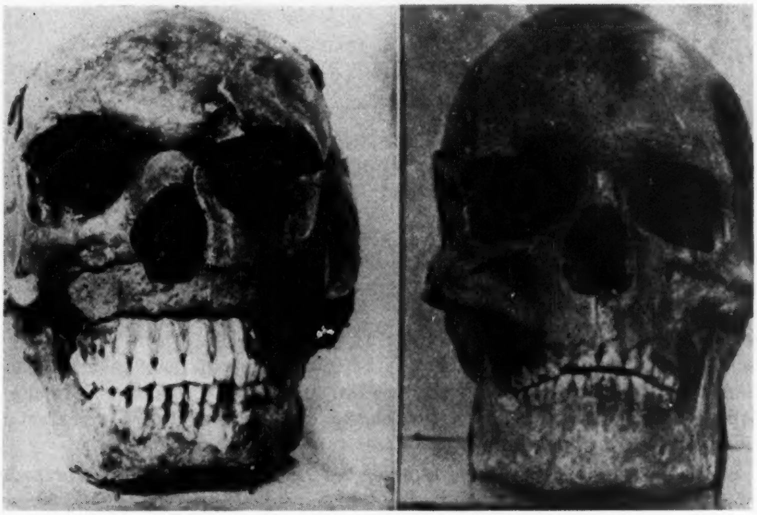

Fig. 3.—Prehistoric skulls were endowed with balanced occlusion. Left: Skull of Le Moustier. Right: Skull of Combe-Capelle. By courtesy of F. Munzesheimer.

Does the functionally perfect type occur in the human race in appreciative numbers or is it just a fantastic creation of some inveterate prosthetist?

This important question will be answered by presentation of evidence.

Let us look firstly at photographs of two specimens of prehistoric man (Fig. 3.) The left skull belongs to the Neanderthal race, the right skull belongs to the Aurignac race. Both skulls have been studied and proved to belong to the functionally perfect type. Munzesheimer[10] has discovered that all fossilized human remains, which are complete enough to permit of a study of mandibular excursions, show that diluvial man was endowed with balanced occlusion.

10. Munzesheimer, F.—Untersuchungen ueber die funktionelle Norm. Reprint. Corr. Bl. f. Zahnaerzte, Nr. 3, 1929.

In order to study the percentage of balanced occlusion in recent man, Mosch[11] investigated the 4,500 skulls of the famous Luschan collection. He found 606 skulls complete enough to be included in his studies (Fig. 4). Column I shows the percentage of skulls having balanced occlusion during all

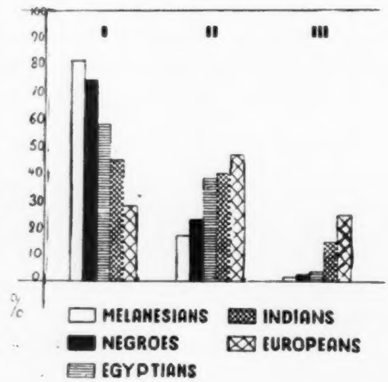

Fig. 4.—Balanced occlusion in recent man (Mosch). I: Balanced occlusion during all mandibular excursions. II: Balanced occlusion during protrusive or lateral excursions. III: No balanced occlusion.

mandibular excursions, column II, during protrusive or lateral excursions and column III, no balanced occlusion. It is interesting to note that increase of civilisation is accompanied by decrease of balanced occlusion. Among the Melanesian or Negro skulls very few belong to the functionally imperfect type, but among the European skulls there are very many.

European children have been studied by Franzmeyer[12] from an orthodontic point of view. This author investigated the mouths of about 7,000 school

TABLE I.

Balanced Occlusion among 340 School Children with Normal Dentition (Ph. Franzmeyer).

Aged	Protrusive Complete Contact	Lateral Complete Contact
6- 8	nearly 60%	70%
9-14	15%	30%
15-18	25%	35%

11. Mosch, E.—Zahnaerztliche Untersuchungsergebnisse der Schaedelsammlung des Kaiser Wilhelm-Institutes fuer Anthropologie zu Berlin mit besonderer Berueck-sichtigung der funktionellen Vollwertigkeit der Gebisse. Diss. Reprint. Zahnaerztl. Rundsch, 40:229, 269, 1931.
12. Franzmeyer, Ph., cit. by Simon, P. W.—System einer biologisch-mechanischen Therapie der Gebiss-Anomalien, Berlin, Meusser, 1933.

children. After eliminating all pathological cases, 340 children with normal dentitions remained (Table I). It is remarkable that more than a quarter of the 15 to 18 years' group still belonged to the functionally perfect type, in spite of all the influences of civilisation and domestication.

This percentage could easily be increased, if more children were treated for lack of molar occlusion during mandibular excursions. In many children, balanced occlusion is precluded by a deep overbite of the front teeth, a condition which can be improved easily in the office of the interested general practitioner by a simple orthodontic bite plate.

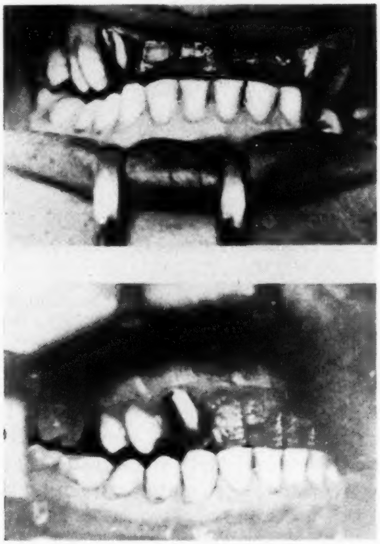

Fig. 5.—Failure of bridgework due to faulty articulation.

Failures due to disregarding the facts of occlusion are frequent. Some failures are attributed, by error, to quite different causes. In many cases, these failures could have been prevented by proper application of the knowledge on occlusion contained in so many textbooks and articles. An example of such a failure, a bridge which was constructed without regard to balanced occlusion is seen in Figure 5. It is not intended to discuss here the workmanship of this bridge. These photographs are shown to demonstrate what happened because the bridge alone had to bear all the stress during masticatory movements. There was no compensating contact of posterior teeth. The metal protection of the porcelain pontics was therefore overloaded: it wore through, bent and the porcelain teeth fell out.

It is a better functional approach to study occlusion during excursions on a suitable articulator (Fig. 6). This method of working leads to a functionally

perfect arrangement with equal distribution of the load. A restoration can be constructed which gives good and long service.

While we were discussing the first illustration, showing the models with facets of wear, the acquisition of a set of such models was recommended for studying. Models with facets provide an excellent means to test an articulator regarding its motility for the articulation of natural teeth. It is evident that only such an articulator could be accepted which would allow the facets of one model to slide along the facets of the other model, after both models are properly mounted.

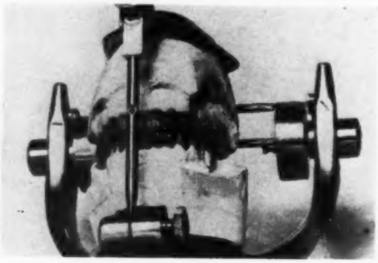

Fig. 6.—Setting up of artificial teeth for a partly edentulous patient with balanced occlusion during excursions. Universal Articulator by Schroeder and Trebitsch.

This reproduction of a natural tooth guidance has been neglected in dental literature. There are dozens of articulators available for full denture work. A test with facet models[13] has shown that only very few instruments can be used for the articulation of natural teeth or partial dentures. Hanau's Articulator Model H and Gysi's Trubyte articulator are not equipped for this purpose. I have this on good authority, from the two authors themselves[14, 15]. Only an articulator with an entirely free axis can meet the very exacting mechanical requirements for lateral excursions along a natural tooth guidance. Among the few instruments which could be used are Stansbery's Tripod[16] Hanau's Kinescope[16] with certain reservations, Terrell's Precision Co-ordinator[16], and the Universal Articulator constructed by Schroeder and the author.[17]

If none of these free axis articulators is available, it is recommended to use for small bridges or partial dentures check-bites and plaster guides, similar to those which are used for indirect inlays. As an emergency expedient for more extended partial dentures, one may mount the models in any adjustable articulator designed for full denture work. However, in this case, the protrusive

13. Trebitsch, F.—Planmaessige Herstellung der richtigen Artikulation bei bezahnten Kiefern. Demonstration. 9th Intern. Congress, Vienna, 1936.
14. Hanau, R. L.—Personal communication to the author.
15. Gysi, A.—Scheff's Handbuch d. Zahnheilkunde, Vol. IV, Zahnersatzkunde, Berlin and Vienna, Urban and Schwarzenberg, 1929.
16. Swenson, M. G.—Complete dentures, 2nd ed., St. Louis, C.V. Mosby Co., 1947.
17. Trebitsch, F.—Die Durchfuehrung der Artikulation mit dem Universal-Artikulator nach Schroeder-Trebitsch. Vjschr. f. Zahnhlkde., 48:31, 1932.

excursion only would have to be recorded at the chairside, transferred to the articulator and used for the setting-up of the artificial teeth. The lateral excursions of that articulator have to be treated with discretion because they may be wrong for this application. The limited mechanical properties of a full denture articulator do not stand up to the articulation of natural teeth. Lateral occlusion would have to be adjusted after the denture has been cured and inserted. While using such a limited articulator for partial dentures, it is a good policy to leave sufficient surplus on the cusps of the artificial teeth for spot-grinding at the chairside.

After having dwelt on the frequently neglected articulation of natural teeth, which is the Cinderella of articulation, balanced occlusion in the construction of dentures for edentulous jaws will now be considered.

Munzesheimer and the author[18, 19] were interested in establishing some objective proof of the influence of the condylar guidance. For this purpose, we made several sets of dentures for one edentulous patient: one with the patient's proper condylar guidance, the others with a guidance either too steep or too flat. Duplicates of these dentures were made of a radiolucent material with metal teeth on the left side of the patient's mouth (Fig. 7). Into the base of the duplicates, amalgam marks were inserted opposite the crest of the upper and lower left ridge. On top of the crest of the left ridges, a narrow strip of tin foil was stuck to the gum with some mastic solution.

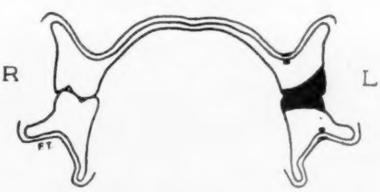

Fig. 7.—Diagram of arrangement for X-ray investigations. Duplicate dentures of radiolucent material with metal teeth and amalgam marks on the left side of the patient. Tinfoil strips stuck to the crest of the ridge.

By extra-oral radiograms, we investigated the occlusion of the metal teeth and the relation between amalgam marks on the denture bases and the respective tinfoil strips on the stressbearing areas.

Dentures and duplicates constructed with the patient's proper condylar guidance gave very satisfactory results (Fig. 8). The metal teeth occluded in centric, protrusive and lateral position; the amalgam marks were in continuous contact with the tinfoil strips. It appears that these duplicates were endowed with balanced occlusion while seated firmly on their supporting areas.

Very different results were observed with dentures and duplicates purposely constructed with a wrong condylar guidance. The condylar guidance for the

18. Munzesheimer, F. and Trebitsch, F.—Neue Pruefmethode kuenstlicher Gebisse. Vjschr. f. Zahnhlkde., 44:1, 1928.
19. Munzesheimer, F. and Trebitsch, F.—Ueber die Bedeutung der individuellen Kondylenbahn. Zahnaerztl. Rundsch., 37:767, 1928.

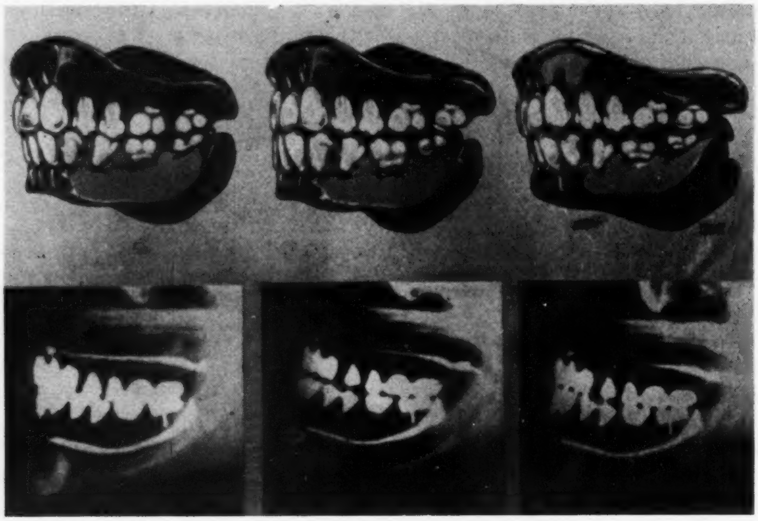

Fig. 8.—Top row: Centric, protrusive, right lateral occlusion of dentures constructed with proper condylar guidance, showing balanced occlusion. Bottom row: Radiograms of duplicates confirm balanced occlusion of dentures firmly seated on supporting areas. Munzesheimer and Trebitsch[20].

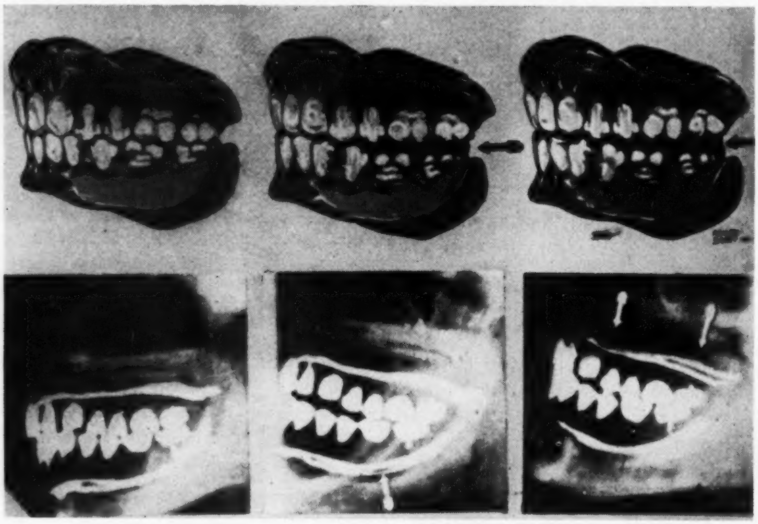

Fig. 9.—Top row: Centric, protrusive, right lateral occlusion of dentures constructed with a wrong condylar guidance. No balanced occlusion. Bottom row: Radiograms of duplicates confirm lack of balanced occlusion. Metal teeth sham contact, denture bases have tilted away from stress-bearing area. Munzesheimer and Trebitsch[20].

20. Munzesheimer, F. and Trebitsch, F.—Dental Prosthetics. Section of the scientific exhibition "Die Ernaehrung," Berlin, 1928.

dentures and duplicates shown in Figure 9 is too flat for this individual. There is a gap between the molars of the upper and lower dentures, in protrusive as well as in lateral occlusion. This gap can be pointed out by putting the blade of a spatula between them[15].

In the radiograms, there is no gap visible between the molars of the duplicates. However, the amalgam marks, which were in contact with the respective tinfoil strips during centric occlusion, have lost their good contact and a crevice separates them in protrusive and lateral excursions. This crevice is sufficient proof that the duplicate dentures have tilted away from their stress-bearing areas. Actually, there is a hollow space underneath these dentures and they lack the static requirements for mechanical efficiency.

These X-ray investigations of full dentures have established objective proof that the action of the temporo-mandibular joint has to be taken in consideration. This can be done by following one of two ways.

One way consists in recording the excursions at the chairside and using the records in an adaptable articulator for a proper arrangement of the artificial teeth; this arrangement can be tried and checked before curing.

The other way consists in recording the excursions at the chairside after curing, with carbon paper. The consecutive grinding with abrasive stones is a late and not always successful recognition of the facts of articulation.

The final illustration (Fig. 10) emphasizes again the crossroad, where everyone is standing who has not yet made his decision. The black areas[21] show the

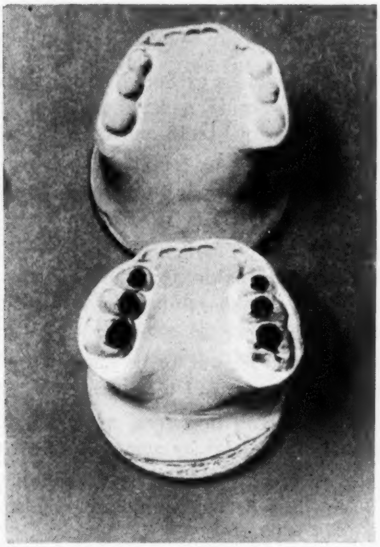

Fig. 10.—Black areas showing the limited field of centric occlusion as obtained in a hinge articulator, in contradistinction to the full functional range of well-constructed dentures.

21. Trebitsch, F.—Zur Frage der Unterkieferbewegung und des Artikulationsgleichgewichtes. Zahnaerztl. Rundsch., 38:2027, 2064, 1929.

small, limited, two-dimensional field of centric occlusion as obtained, for instance, with a hinge articulator. It represents but a small section of the wide, three-dimensional range of function for well-balanced dentures. We know that cusp interference and tilting is the lot of dentures made for centric occlusion only, with all the sad sequelae for both patient and operator. We know that well-balanced dentures can be made efficient in every respect, a pleasure for both patient and dentist.

Should we now select the sad, or the pleasant road? And are we prepared to put that additional amount of time and effort into it?

I have attempted to demonstrate that the basic facts of occlusion play a big role in the natural dentition as well as in the construction of artificial restorations and dentures. Observation of the mandibular excursions should be an essential part of every chairside examination. Taking care of the mandibular excursions means less failures, more benefit for the patient and greater satisfaction for the operator.

Summary and Conclusions.

1. Balanced occlusion of natural teeth has been found to be the original norm of the human dentition.

2. Natural balanced occlusion offers the optimal equilibrium of the masticatory organ in functional, static and prophylactic respect.

3. Observation of the excursions of the mandible is an essential part of every dental examination.

4. Dental performances should be executed with due regard to any balanced occlusion being present. They must never interfere with mandibular movements guided by both factors, natural teeth and temporo-mandibular articulation.

5. Whenever balanced occlusion is found lacking in a dentulous or partly edentulous masticatory organ, it should be the aim of bite rehabilitation to study whether and by what branch of dentistry the benefit of balanced occlusion could be given to such a functionally—and in a preventive sense—imperfect dentition.

6. Many articulators are available for the articulation of full dentures, very few for the reproduction of the joint and tooth guidance of dentulous or partly edentulous patients.

7. Emergency measures are set out to be employed when no articulator is at hand designed for the reproduction of a natural tooth guidance.

8. For the construction of full dentures, attention has to be paid to the action of the temporo-mandibular joint by some adequate method.

9. Disregard of the action of the temporo-mandibular joint may result in dentures which have been proved, by X-ray examination, to lack the static requirements for mechanical efficiency.

10. Printing and reading of scientific findings does not lead to any progress in therapy, unless these findings are digested by an operator who is prepared to do his best, and carries his new understanding into his daily work.

DENTAL MATERIALS

Current Notes No. 4*

More on Direct Acrylic Restorations.

In current overseas literature every month brings forward articles on the "self-curing" acrylic resins and it is anticipated that there will be many more in the future. The latest reports deal chiefly with the new material as applied to direct restorations.

In Current Notes No. 3 reference is made to Malson[1], who described a method for applying constant pressure on the acrylic restoration during its polymerisation in the tooth cavity. There is no doubt that positive continuous pressure during curing is a vital necessity and herein lies one of the chief disabilities of direct restorations. It is difficult to maintain pressure for the necessary time which, with the materials available at present, is at least six minutes. Every practitioner will realise that finger pressure on a matrix strip for such a long time would require patience and determination. Mechanical aids are an inevitable development and further suggestions are given by Meyer[2] for the construction of pressure matrixes for various cavities. He claims that if finger pressure on the matrix is relied upon imperfect restorations and fatigue for both dentist and patient will be the result. The use of pressure matrixes will free the practitioner for other work while the resin is curing.

Another article by Salisbury[3] appears in *Dental Digest*. This writer has been contributing over a period of some eight years on the subject of direct acrylic restorations, but it is obvious that the earlier materials he used were crude in comparison with the new acrylic resins now available for this purpose. In the light of recent developments, Salisbury has clearly set out the procedure to be adopted for the various classes of restoration. Full clinical details are given and for those who wish to experiment further with direct acrylic restorations this article will be found useful.

In briefly reviewing developments over the past 25 years in materials for anterior fillings, Franzwa[4] points out the many advantages of the direct acrylic material over silicates. He has an alternative suggestion of using gutta percha for providing pressure on the matrix strip during the polymerisation of the resin. This may be suitable for some types of cavity, but whether it is effective in maintaining pressure in others remains to be seen.

Novel Use of Self-curing Resin.

A new application for the rapid curing acrylic resins is suggested by the Greene brothers[5]. Taking advantage of its lack of adhesiveness to tooth

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*Contribution from the Commonwealth Bureau of Dental Standards.

1. Malson, T. S.—Acrylic as a restorative material: Dent. Digest, 56:58-62, 1950.
2. Meyer, H. J.—Pressure matrixes for acrylic restorations: Dent. Digest, 56:124-5, 1950.
3. Salisbury, G. B.—Present status of direct acrylic restorations: Dent. Digest, 56:202-9, 1950.
4. Franzwa, C. G.—The new resin materials for anterior fillings: Dent. Survey, 26:655-9, 1950.
5. Greene, N. A. and Greene, L. L.—The use of rapid setting acrylic resins as a casting medium in the direct technique: Dent. Digest, 56-254-7, 1950.

tissues and the fact that it vaporises without residue at temperatures above 400° F., acrylic resin can be used in place of wax in the preparation of casting patterns for the various types of crowns and inlays. Its relative freedom from distortion, its greater tensile strength, the ability to establish occlusion and contact points accurately are factors in favour of using methyl methacrylate. As the material can be finished and polished thoroughly the final restoration requires practically no finishing on seating.

Of course, resin free from pigment should be used otherwise a residue will be left on burning out. The authors of the paper, however, colour their material with a purple dye to increase the visibility of the patterns in the mouth. For establishing occlusion, yellow articulating paper is used for contrast.

Care of Wax Patterns.

Speaking of casting patterns, Phillips and Biggs[6] have written a timely article on the influence that storage time and temperature and the temperature of manipulation, have upon wax patterns. Experimenting with M.O.D. patterns they concluded that for accuracy the patterns must be invested immediately after removal from the preparation. Most of the distortion occurs during the first two or three hours of storage depending on the temperature. Distortion is accelerated as the storage temperature is raised and it is suggested that if storage of the pattern is unavoidable a refrigerator should be used. Even so, it has been found at this Bureau that the accuracy is still not as good as that obtained by investing immediately.

A number of photographs shown in the article clearly demonstrate the surprising amount of distortion that results on the storage of wax patterns at room temperature. Under given storage conditions the amount of distortion is least when patterns have been melted and poured and greater if moulded. The higher the moulding temperature the less the distortion. Inlay patterns that have been subjected to patching and pooling show maximum distortion.

The main point is to make sure that patterns are invested immediately, after which they can be cast at any convenient time, for once the mould shape has been fixed and the investment set there would be practically no further change until the mould is heated. If patterns have been stored in a refrigerator they should be allowed about eight minutes to come to the temperature of the room and then invested immediately.

6. Phillips, R. W., and Biggs, D. H.—Distortion of wax patterns as influenced by storage time, storage temperature, and temperature of wax manipulation: J.A.D.A., 41:28-37, 1950.

The DENTAL JOURNAL of AUSTRALIA

EDITORIAL DEPARTMENT

THE YOUNG GRADUATE

There was a time when the young graduate could, upon the conclusion of his course of studies, look forward with some confidence to obtaining employment as a junior assistant without any great difficulty. This ability to obtain suitable employment became far simpler during and immediately following the war years, when he could not only select the area in which he sought employment but also ask for remuneration far exceeding that which had formerly been paid for such assistants.

The war years have now passed, however, and the members of the profession serving in the forces are for the most part again safely ensconced in their various practices. During these post-war years the University has been discharging its obligation to ex-servicemen and women desirous of obtaining training in dentistry and so the number of graduates has increased rapidly. Thus, no longer does the happy position for the graduate exist where he could spend some time in carefully choosing the position which he might accept.

There have been numerous discussions as to the worth—both in the sense of the ability to earn money and in the sense of professional training—of the new graduate. The medical graduate is enforced by law to obtain further experience in medicine by appointment to public hospitals as a resident medical officer. It has been decreed, however, that the dental graduate has sufficient training and experience to assume full responsibility for his practice of dentistry immediately upon graduation. This automatically excludes the absorption of new graduates into public hospitals and casts them all on the open market to obtain either assistantships, to buy practices, or to enter some form of public service. The usual procedure has been for the graduate to seek an assistantship in order to gain his experience and to have the benefit of the guidance of a more senior practitioner so that he, too, might serve the public more skilfully.

In all matters the law of supply and demand invariably applies, and undoubtedly it will in the matter of remuneration to graduate assistants. There are certain points, however, that we might well bear in mind in such matters. Firstly, it might be well to bear in mind the rates of pay which are now in force for technical services ancillary to the dental profession. It would indeed be lamentable if even the most junior graduate were ever forced into the position

where he was expected to accept remuneration only the equivalent of that paid to a technician. Even though, for some short while, from a financial aspect the benefit to the employer be slight, it would be far better to engender in the young members of the profession a spirit of responsibility and an idea of the standards which they must attain and maintain by the payment of an adequate remuneration.

Secondly, it is extremely difficult for the young to look a long way ahead and graduates may accept positions which temporarily seem attractive in that the immediate financial return is greater than that which can be obtained as assistants today, but which in some years' time might prove to be some sterile and routine form of service in which they find no inspiration and no ability to enhance either their own position nor that of the profession.

The inability of the young graduate to obtain suitable accommodation is still a great limiting factor in the numbers who are able to give service in many country areas. It should be one of the normal extensions of professional service to establish practices in many of the areas which for so long have been without adequate dental service, but there seems little prospect of any solution to this problem unless these communities themselves assist by making accommodation available.

At the recent graduation ceremony at the University of Sydney, the thousandth graduate obtained his degree as Bachelor of Dental Surgery. This means that we have an influx of young, keen and well-trained men who, because of their large numbers, could easily exercise a deciding influence in the future of the profession. It is the duty of the older members of the profession to do all in their power to see that these members are absorbed gladly and quickly into our ranks to carry on the ideals and standards which have already been set.

CORRIGENDUM

Line 32, page 460 in the September issue of the "Dental Journal" should read:—

"Your Excellency, distinguished guests, ladies and gentlemen."

News and Notes

HONOURS AND AWARDS

PROFESSOR A. J. ARNOTT.

Advice has been received that His Majesty, the King, has been graciously pleased to appoint Lieut.-Col. Alwyn James Arnott as Honorary Dental Surgeon to His Majesty.

The work of Professor Arnott in the professional sphere of Dentistry needs no reiteration, and it is indeed fitting and pleasing to see that his military career has now been so recognised.

Prior to the recent war, Professor Arnott was an honorary major in the Australian Army Medical Corps (Dental Services) and shortly after the commencement of hostilities he took over the duties of A.D.M.S. (Dental) Eastern Command. Later he went to the United Kingdom, together with Lieut.-Col. Kenneth Starr, where he carried out facio-maxillary surgery in association with Sir Harold Gillies and Mr. Kelsey Fry at the famous centres of Basingstoke and East Grinstead. On his return to Australia he was appointed Officer-in-Charge of the No. 1 Facio-maxillary and Plastic Surgery Unit at the 113th Australian General Hospital, where for some time the majority of the plastic surgery for the Australian troops was carried out; Lieut.-Col. Kenneth Starr, O.C. Surgical 113th A.G.H., was the Plastic Surgeon to the Unit.

Professor Arnott was then appointed Consultant Dental Surgeon to the Australian Army Dental Corps. In this role he visited the various stations throughout Australia and the South-West Pacific area in which Australian troops were serving. He held this position until he returned to his duties as Dean of the Faculty of Dentistry, University of Sydney.

The members of the dental profession in Australia, and particularly the members of the Services, extend their heartiest congratulations to Professor Arnott upon this great honour.

DR. N. E. GOLDSWORTHY.

The Rockfeller Foundation recently awarded Dr. N. E. Goldsworthy, Director of the Institute of Dental Research, Sydney, a special travelling fellowship.

It has not been a function of the Rockefeller Foundation to sponsor dental research in the past and it is doubly gratifying, therefore, to find that the first time upon which they have undertaken such a duty they have gone beyond their own country and awarded a fellowship to Dr. Goldsworthy.

Dr. Goldsworthy has already left Australia by air to spend six months in the United States of America, firstly to work with various members of research staffs and, secondly, to inspect research projects that are being carried out in the United States of America. During his time abroad, he also anticipates attending the meeting of the International Association for Dental Research which is to be held in Indiana in March. On his trip to America Dr. Goldsworthy was requested to break his journey at Honolulu in order to inspect the University of Hawaii and address the research personnel of the Medical and Dental Services of the United States Navy.

The personal benefit to Dr. Goldsworthy will be great but the benefit of the experience which he will be able to pass on to the dental profession will be inestimable. We are indeed proud that such an honour has been bestowed on the Director of the Institute of Dental Research.

INTERNATIONAL DENTAL CONGRESS

The International Dental Congress is being held in London from 19th to 26th July, 1952.

Any person desiring to attend the Congress or to present a paper or an exhibit should apply to the Office of the Association where application forms for membership, for the presentation of material, and for accommodation are available.

EMERGENCY TREATMENT DURING CHRISTMAS VACATION

We are pleased to inform members of the Association that the roster of dentists for emergency treatment during the Christmas holidays functioned most efficiently. There were 35 dentists on the roster and 225 people who sought treatment were attended to.

THE AUSTRALIAN ORTHODONTIC ASSOCIATION

This Association has been recently formed in Melbourne. The office-bearers are:

President: Mr. John Heath.

Vice-President: Mr. R. S. Gargett.

Secretary and Treasurer: Mr. F. A. Soper.

Membership is open to Australian orthodontists; persons undertaking post-graduate orthodontic training may become Associate Members.

JENNINGS SHIELD

DENTISTS v. DENTAL UNDERGRADUATES.

The 15th Annual Cricket Match for the Jennings Shield, played at Woollahra Oval on 13th December, 1950, resulted in a win for the Dentists.

Trophies were awarded as follows:

Batting Trophy:	Dentists—A. Barnett.
	Undergraduates—B. Burns.
Bowling Trophy:	Dentists—K. Binns.
	Undergraduates—K. Titley.
Fielding Trophy:	Dentists—R. Norton.
	Undergraduates—W. Sanders.

ANNUAL CRICKET MATCH

DOCTORS v. DENTISTS.

The Annual Cricket Match between doctors and dentists will be held on 7th March, at 10.30 a.m., at the Sydney Cricket Ground. All members are invited to attend the match and, should any visiting member desire luncheon, it is requested that he advise the Office of the Association by 3rd March.

SUPPORT YOUR OWN JOURNAL

All members of the New South Wales Branch of the Association and other subscribers are asked to peruse the advertisements herein and to support those dental supply houses and others whose announcements are published in "The Dental Journal of Australia."

HELP THOSE WHO HELP YOU

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